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PRACTICAL PATTERN MAKING

A PRACTICAL WORK ON

The Art of Making Patterns, Written by a Pattern-Maker with Thirty Years' Experience. Contains Information on Pattern-Making and Pattern-Makers in General, also a Detailed Description of the Necessary Materials and How to Use Them. Then the Tools, both Hand Tools and Machine Tools, with Special Chapters on the Lathe, the Band Saw and the Circular Saw, with Many Examples of Work Which May Be Done on These Machines.

A Complete Section of Illustrated Examples of Pattern-Work in Wood, with Many Pages of Metal Pattern Work, Gating and Plate Work, both Vibrator and Stripping Plates, are Shown. Specific Instructions for Plaster Work are Given. And Finally, the Cost, Marking and Record of Patterns are Explained and Illustrated.

BY F. W. BARROWS

SECOND EDITION

REVISED & ENLARGED

Fully Illustrated by Engravings made from Special Drawings for this Work by the Author

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PREFACE.

In presenting this new edition of Practical Patternmaking, we have endeavored to make the book more attractive and interesting by the addition of new material at places which seemed somewhat incomplete. The substitution of this new text for such part of the old volume as, in our opinion, was of less interest to the patternmaker, improves the general tone, and makes the entire book more useful and instructive to the trade.

The specific examples, which could easily be increased in number, there being no lack of material, if the size of the work did not restrict their number to the allotted space, have been selected with the purpose of making the ones given of as great scope as possible, that they may be of wider application; thus making this part cover a larger field of pattern work.

All technical books must necessarily be only a more or less incomplete record of results attained by the efforts of the individual in the line of work or study to which the book is devoted. It is obviously impossible to make any such record entirely complete in a single volume; and in selecting the material for a book of this kind, much that is desirable must be discarded, retaining only the best, or that which seems, in the judgment of the author, to be of the greatest benefit to the average tradesman.

If the intelligent reader, making due allowance for lack of space, finds that this book seems to cover the field of patternmaking thoroughly, giving satisfaction to those seeking information, and interesting those who are willing, or pleased, to learn from the experience of others, then we shall feel that our time has not been wasted in useless effort.

Many of the subjects illustrated and discussed in this treatise originally appeared in the columns of the "American Machinist," others were published in "The Patternmaker." And in "Wood Craft," and "Castings," the worthy successors to "The Patternmaker," appeared the new material used to make this edition more presentable. To these publications we are indebted for the courtesy extended.

Firm in the belief that this revised edition will find favor in the eyes of my fellow craftsmen, I am,

Yours very truly.

F. W. Barrows.

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PART FIRST.

INTRODUCTORY.

PATTERNMAKERS AND PATTERNMAKING.

CHAPTER I.

PATTERNMAKERS AND PATTERNMAKING.

If there should be as much time and skill devoted to the search for the original patternmaker as has been displayed in the search for ancestors who may be exhibited without detriment to our present social and moral standing, it would perhaps be found that he was known among his neighbors as the best man to build that new house for the mayor, or the sty for Farmer Jones' pigs, and, in fact, anything wanted, which was constructed principally of wood.

Perhaps it was a plough which first demanded the services of a patternmaker, and as the plough had always been made of wood and constructed by the party mentioned above, what more natural than to employ the same capable individual to construct the desired pattern? Or, what is still more probable, that this same talented man, whose many accomplishments have been handed down through generations to the present skilful members of the trade, originated the pattern idea and used one of his own wooden mouldboards for the first pattern. Some of the castings made to-day look as if the original pattern were still in use.

Later, as the wood-workers became divided into classes, each individual following that particular branch which liking or necessity dictated, it seems to me most probable that each branch would be called upon to construct such patterns as might be needed for castings used in their line of business. With the demand for castings constantly increasing, the moulder commenced to be heard, and the sound of his voice has never since ceased.

Men began to see that, whatever the casting, there were certain rules to be followed in the construction thereof: it must have draught, and the shrinkage of the casting must be allowed for. Even at the present day, if these simple rules are transgressed, it causes the moulder to grieve and the man who pays to swear.

As you couldn't reasonably expect every wood-worker to know about these little things, the pattern work would naturally come to such as had shown their ability to construct useable patterns; this man would soon have work enough to keep him busy on patterns alone, and as a consequence the patterns would improve.

As the struggle to produce more castings grew intense and it became necessary to have better castings, and more of them, the wood patterns were not substantial enough, or perhaps the wood pattern was used up, and some genius hit upon the happy idea of using one or more of the castings already made for patterns. The next step was that the moulder, who is ever watchful of the master's interests when it happens also to be his own, suggested the gating of the patterns, having noticed the castings as he dumped the mould, with their runners tying them all together, making one pattern of the flask full. This shifted a portion of his own work upon the patternmaker. To be sure, he got better castings and more of them, but this was entirely the result of the patternmaker's efforts.

Still the demand for more and better castings at lower prices would not be satisfied. As a result of the effort to supply this demand, we have now the moulding-machine, and a good many of them, which will do anything that the moulder can do and do it in a very superior manner, so the advertisements say. The moulding-machine lowered the cost, as the patterns are so arranged that less skill is required of the moulder, thus making possible the employment of cheaper help in the foundry, increasing the output and decreasing the cost of production.

So we have advanced from the crude, inaccurate wood pattern, made by the wood-chopper of prehistoric days, to the highly finished metal patterns now required for the moulding-machine, and from the all-round individual of that time to the highly specialized patternmaker of to-day. The patterns that are constructed of wood, by the skilled members of the craft to-day, show evidence of good judgment in the selection and arrangement of the material, although there are some of us who are inclined to think that if the making of the wood were intrusted to us we could produce a very superior article in this line, and one which would be less subject to the influence of the weather. However, the man who constructs the pattern for some light, frail piece so that it gives good service and keeps its shape, is still entitled to some credit for so doing.

The durability of the wood pattern depends greatly upon the wise selection of material, and by this I don't mean the *kind* of material, because this is usually dictated by the firm, or by the foreman; but if the entire stock of lumber is limited to two boards, there is a choice between the two, and it is in making this choice that the expert shows his skill. Sometimes, it must be confessed, it seems as though each one of the two was a little *poorer* than the other.

For large patterns or such as will be used but a few times there is probably nothing to be had better than white pine, while for small and medium-sized pieces, especially if they are to be much used, a harder wood is better. Many prefer cherry; for myself, I prefer mahogany, and for light, thin patterns would use what is known as Mexican wood. For short, thick forms, especially such as may be made almost completely in the lathe, Cuba wood is best. Whatever the material, it must be thoroughly seasoned, and from old trees in preference to young timber, as young timber, while it is usually much harder, is also much more liable to spring and twist.

In assembling the pieces which go to make up the complete pattern, glue is much used; here again experience counts, and even the boy has found that it is quite a knack to make glue joints that are really substantial. Wherever possible, glue joints should be nailed or strengthened with screws. Loose pieces are sometimes necessary on wood or metal patterns, but it is a good rule to make them as few as possible. They add to the cost and are often the cause of poor castings.

Many shops use two colors of varnish, one for core prints and another for the body of the pattern. This is probably a good plan if not carried to extremes, as in the case of some regular stock pattern which is in use pretty much all the time. The moulder doesn't need to be continually reminded that he must set a core in this mould, and the patternmaker can employ the time saved to much better advantage.

After the first coat of shellac is the proper time to wax or putty a pattern. This operation often gives more satisfaction if the whole job can afterward be covered with black varnish, for black varnish, like charity, covers a multitude of sins. Putty will probably wear longer, but it isn't quite as nice to handle, and doesn't harden so quickly as wax, although when it has set it is much harder. Beeswax, unless it is pure, and put on hot, will not adhere to a wooden pattern.

When we come to metal patterns, the master pattern, if one is required, is generally of wood, thus calling for the services of the woodworker, and the castings for gating are usually of brass; so the brass finisher, with his knowledge of soldering, is called upon to finish and gate the castings. Thus was the original *metal* patternmaker drawn from the ranks of the brass finishers. To-day the competent metal patternmaker is called upon to finish not only brass patterns, but also those made of cast-iron, aluminum, steel, and wrought-iron. He must also be familiar with the use of machine tools, the lathe, the planer, milling-machine, and drill press. So that the patternmaker of to-day may be said to have added to his previous knowledge of mechanical drawing, woodworking, moulding, and brass finishing, no small part of the machinist's trade.

CHAPTER II.

HOW SOME FOLKS MAKE PATTERNS.

THERE are about as many different ideas in regard to the construction of any one pattern as there may be good ways of making the pattern. Where is the patternmaker who, in looking over patterns he knew were made "outside," has not noticed that "they don't do their work as we do"? This only shows that your way is not the only way, and very likely not the best way of doing the particular job under inspection.

Now, as a pattern is only a "means toward an end," which end is not always in the foundry, although a good many patterns are here brought to an early and untimely end, we should not consider the pattern of more importance than the end for which the pattern is made. This is sometimes the case with those who think that the moulder is simply a machine which, if supplied with any kind of a pattern, is bound to turn out a good casting. Moulders have some ideas in regard to moulding patterns which the patternmaker should respect; and if he would try to construct the pattern so that it would mould according to the moulder's ideas of right, I think that all hands would be better pleased with the result. The great idea is to get a nice casting, and where the patternmaker and moulder work in harmony this is usually accomplished.

The patternmaker certainly has the right to criticise his own work, and perhaps the work of any of his fellow-craftsmen; but let his criticisms stick to hard facts, and not be based on prejudice, as I am afraid is apt to be the case. I have noticed, and so have you, I presume, that when some outside pattern has found its way to our shop, how many faults we seem to see in it. Perhaps the whole gang will get after it in this style: There is a pattern which Overtheway & Co. have made, and it has been sent to our shop to mould, and has found its way to the patternmaker. If it is a new pattern, any of the help can see that it is a stranger as soon as they set eyes on it; then see how it will be criticised. Perhaps away down in our minds we can see that it is a neater-looking, better-constructed job than we ever made, or could make; still let us see if we can't find some fault in it.

Yes, there it is—"See that short grain?"

"How long do you suppose that will stand in the sand? They hadn't ought to have put in that short grain."

There was really no way to avoid the short grain in this case, perhaps, but that makes no difference; we set out to find some weak spot in this pattern, and we are bound to do it, and as long as no one has the courage to speak for Overtheway & Co., their reputation as first-class workmen will suffer in the judgment, or, more correctly, in the conversation, of present company.

"Here's another thing—a 2″ core print that just fits the box."

"We always make the print a little larger because you know the core will swell a little in baking—at least, that 10″ cylinder pattern I made, I left the core print a little full, and

of course a 2″ print
size.”
your small work ever
right spot. The core
and perhaps it will
have always laid the
when by a little experi-
that a 2″ core would, if
the box after baking, and
of the box would be *just*
are bound to condemn this

little three-cornered piece
but leaves two in its place
of the present company) can
what is a fillet good for if it
As for me, I would rather
corner, put in neatly (as in the
of the fillets that pretend to
less, but are really no nearer
than the present specimen.
fillet used for?
or to prevent shrinkage in a
the casting, or look bad, and it
moulder happy, if you think he

the present specimen fill all of
There is really only one fault about it.
but see how much easier it can be
regular fillet—no feather-edges to
in place there will be no feather-

edges to roll up. In short, it is really better, so far as durability goes, and just as good in every other particular, except perhaps in regard to looks, and this, very likely, is only a cultivated taste like smoking, for instance. I presume that the casting will be just as strong as though the fillets were all perfect arcs.

"And now here is one more thing. See this chalk-mark, '2off'? That means two castings wanted from this pattern. See how cheaply we have sold ourselves? Here is a pattern that we haven't been able to find any really serious fault in, even though our criticism was founded on prejudice, and was all on the supposition that this pattern was intended for a first-class job, and here is the proof that it was intended for two castings only. We shall have more respect for Overtheway's work after this."

Now, be honest, and own up that this criticism, or rather this fault-finding, we have been indulging in, was nothing but prejudice. This is very apt to be the case with all criticism. We condemn others' ways of doing work only because they are different from our own, when in many cases our way is the one that would be condemned by a fair judge.

If you wish to be at the head of your trade, strive to adopt all of the best ideas. If your own work won't bear comparison with Overtheway's, why, condemn your own and try to improve on their ways.

If you are so short-sighted as to stick to your own way after you have found that it isn't the best way, or are so bigoted that you can't see any faults in your own work and be willing to acknowledge them, I am pretty sure that you will be left far behind in the race.

CHAPTER III.

SOME METHODS.

AN old patternmaker gives a method of obtaining the weight of irregular-shaped castings by immersing the pattern in water, measuring the displaced volume of water, and multiplying the result, in cubic inches, by .26, the weight in pounds of one cu. in. of iron.

Another thinks that it would be simpler to weigh the displaced water, or, better yet, to weigh the pattern itself. But as the material of which the pattern is made varies so much in weight, the result would be very uncertain. Still, as the weight of water is practically constant, by weighing the displaced water he would probably obtain the desired end as accurately as by the measurement of displaced water, and more especially as an error in measurement would, in the final result, become 7.21 times greater than an error in weight.

I should consider that both gentlemen were advocating very bad practice when they suggest immersing wooden patterns in water, and would advise weighing the pattern, as the result would, in either of the three methods, be only an approximation. The difficulty arising from the varying weight of wood could be lessened by cutting a small cubical block from the same plank used to make pattern; this piece to contain 3.85 cubic inches. Then the weight of pattern divided by the weight of this block gives the weight in pounds for a *solid* casting from the pattern.

I find many mechanics using the sense of feeling in making fine measurements, the articles employed being usually a steel scale and a scriber or the point of a knife. In using a pair of dividers, their setting may be tested by placing one point *in* a line on the scale, using it as a centre, the dividers being held nearly parallel with the flat side of scale, the legs of the tool as nearly parallel with the lines as possible; then if the other leg is slowly brought down to the required line, the spring, or lack of spring, noted by the sense of feeling, as the other point enters the required line, will show whether they are correctly adjusted. There are some things that we can see better with our fingers than with our eyes.

About scales, when the drawing comes into the pattern shop marked "Use dimensions only," and drawn to any scale whatever, there are usually many points which will have to be scaled by the patternmaker, and if the scale of the drawing is such as can be measured by the ordinary steel rule it saves much arithmetic and—talk.

Imagine the patternmaker getting a drawing marked "⅜In. = 1 In." and then having to figure out all of his measurements to this scale. The fact that this scale made the drawing fit the standard size sheet doesn't seem to me of enough importance to warrant the risk of condemning the patternmaker to everlasting punishment by its use.

An old friend of mine was in the habit of classing the graduates of our technical schools, or such of them as were privileged to add M.E. to the name given them by their parents, as "pyrotechnic" engineers, and I sometimes think that his title wasn't so far off after all, for the "pyrotechnic" engineer might be expected to produce, as he sometimes does, "pyrotechnics," as witness the language of the patternmaker in the case cited.

The patternmaker, if he is so inclined, may, by consultation with the draughtsman or with the designer, assist in eliminating some faults of construction as regards the pattern or the casting; and no fair minded, conscientious draughtsman will take offense at *honest* criticism of this kind.

CHAPTER IV.

PATTERNMAKERS.

PATTERNMAKERS may be considered as toolmakers for the foundry, and as the so-called toolmaker needs to understand the machinist's art in all of its details, so the patternmaker, to be of any real use, must understand the moulder's trade, in order to make the special tools or patterns without which no castings could be produced. He should not only be competent to produce patterns for staple goods, but must continually be making new articles, or old ones in a new form.

To this end he must be able to read mechanical drawings, and he is, in fact, constantly expected to read so-called drawings which are far from being mechanical and which, like Johnny's picture of the cow, would be unrecognizable without the title, which title is perhaps the only clew to the meaning of the drawing.

Behold, now, the patternmaker in the rôle of Sherlock Holmes; the draughtsman (?) may have as crude an idea of the article delineated as the boy had of the horse, which he described as an animal with a tail and four legs, one at each corner; still, if S. H. is in any sense worthy of the name of patternmaker, he will be able to follow the "clew" through the drawing, and point out the tail, and each of the four legs, and then to join them all together in a more or less complete and artistic whole.

Speaking of drawings, I am reminded of an old acquaintance who consented to give a young friend instructions in mechanical drawing, and did so, the complete course in one lesson, by instructing the pupil in the following words: "Make all the lines you can see, full lines, and those which you can't see, broken lines. That's all there is to it."

After absorbing all of the information given by the drawing, the patternmaker usually makes a full-size lay-out of the piece to be made. He must now study the shape of the piece, and plan to so construct his pattern that the resulting piece of work will be strong and serviceable, and enough like the drawing that it will not, like Johnny's cow, require to have the name printed on in order that it may be recognized by its creator—the pattern, not the cow.

This faculty of being able to see things before they exist—and, by the way, this is different from the faculty for seeing imaginary things, which may be acquired by frequent internal applications of the contents of the alcohol jug—this faculty is, I say, one of the necessary qualifications of a good patternmaker.

Without this skill, or foresight, the pattern becomes a freak job, and the only way to save it from the scrap-pile is to make up the bad spots with beeswax and give it a heavy coat of black varnish.

PART SECOND.

MATERIALS AND TOOLS.

CHAPTER I.

LUMBER.

For the general line of pattern work there is probably no better material to be found than white pine. White pine is light, easily worked, takes glue and varnish nicely, and is fairly durable. As there are many patterns made for present use only, these points cannot be overlooked, else the labor cost gets too high.

When I say that white pine is easily worked, I mean that it not only offers little resistance to cutting tools, but that it is not "hard on tools." A nicely seasoned piece of old timber can be sliced off by a sharp chisel or gouge with a facility only to be equalled in cutting whitewood timber. The tool, when cutting pine, does not dull very quickly, which makes it a pleasure to work this timber.

Whitewood has the serious objection of being too susceptible to atmospheric changes. It also seems to be always shrinking; in short, one of the earlier settlers in Ohio said that there was a great deal of whitewood timber in that country; he himself had cut a tree which squared 24" for twenty feet in length. This log he had sawed into planks and used for a floor in a 20 x 30 building. It took just fifteen planks to cover the floor, "but the plaguey stuff shrunk so fast that I had to put in one new plank each year, and in fifteen years I had an entire new floor."

Shrinkage and swelling of timber is caused by atmospheric changes; temperature and moisture, or lack of moisture, both having some effect. Increase of temperature, *without* a corresponding increase of humidity, will always cause shrinkage, while an increase of moisture invariably causes an increase in the size of the piece of timber under consideration, the expansion being greatest in a radial direction—this radial direction referring to the position of the plank in the log, which can be easily determined by examination of the cross section. As all timber grows in concentric layers, it is evident that a radial line (of the tree) must always be at right angles with these layers.

Again, as all timber is porous, and as these pores, or pipes, run lengthwise of the log, and in the green, living tree are filled with liquid, the evaporation of which seasons or dries the timber, causing at the same time shrinkage, it is evident that the fluid near the ends of the log will evaporate fastest, and thus the ends will season, or shrink, first, the shrinkage strain often causing timber, both logs and planks, to crack at the ends.

Moral: Don't put green or water-soaked lumber in the drying-room.

Temperature, and perhaps moisture, causes a change in the length of timber; higher temperature causing expansion, which is partly offset by the changes due to increased evaporation of the contained moisture. In the case of "cross-grained" timber, it is evident that the same conditions which affect the width of a board will, in a lesser degree, affect its length.

This question of shrinkage—or, more correctly, the neglect of it—has ruined many an otherwise good job. At its best, wood is very sensitive to moisture and should not be exposed to its influence.

In mahogany we have a timber which, having a hard, dense surface, is invaluable for small, fragile patterns or for patterns which are in constant use. It is more difficult to work than pine, and doesn't take varnish and glue so readily, but it will stand lots of abuse.

In selecting mahogany for patterns, use only the straight-grained timber. Mexican or Cuba wood is best, what is known as baywood being but little, if any, better than pine.

Mahogany, being very close-grained, is not so susceptible to atmospheric changes as pine. This statement is perhaps unnecessary, as any close-grained timber is proof against slight changes in temperature and humidity; because the term "close-grained" means small pores, and we all know that it is hard to force moisture through small holes, with only the slight variations in pressure caused by atmospheric changes. Therefore, let us use some kind of close-grained timber for such patterns as are expected to bear hard usage. And for the same reason that the old farmer "didn't care what color the new school-house was painted, so long as it was red," let us use mahogany; you can't find any better (color) timber.

Cherry has proved itself of value in making durable patterns; in fact, many (otherwise) good patternmakers prefer it to mahogany, and it *is* cheaper. It is hard, but not so nearly immune to the influence of temperature and humidity as mahogany.

On the whole, cherry is very good pattern material, the item of price, with its other good points, making it a strong rival of mahogany. One very important point in cherry is this: Don't use young timber or you will suffer remorse.

Maple and birch are both growing in favor, especially for lathe work. They take a good, smooth finish, and if kept well varnished will make a good fight against the ills to which all patterns are subjected.

Until we patternmakers are able to get some material which is less sensitive to atmospheric changes than wood, we must go on making patterns which strive to become barometers; and we must endeavor to overcome this "hereditary" tendency by the exercise of such judgment as we may be endowed with and be permitted (if it don't cost the "old man" too much) to use.

CHAPTER II.

VARNISH.

Patternmakers use varnish to fill the pores of wood patterns and thus make them more or less impervious to moisture. Any old varnish will do this, but when it is also expected that the varnish will give a smooth, hard surface, we must be careful in the selection of our varnish. Another vital point is that it must dry quickly. Thus our choice is narrowed down until, in place of being able to use any varnish, we are really restricted to the one kind—shellac varnish.

There have been placed on the market many substitutes for shellac varnish, most of them "just as good," and some of them a great deal better, the advertisements say, than shellac. This alleged improvement is usually in the price alone, and the lower the price the greater the improvement, as the agent (who knows) will tell you. When you can buy shellac varnish for less than the price of grain alcohol, you may be sure of getting your money's worth—in quantity, if not in quality.

There is nothing to be had quite as good as shellac cut with grain alcohol. I have tried nearly everything that has been put on the market for the last twenty years, and have gone back to the real gum and grain alcohol, mixing it myself, and getting results that are entirely satisfactory.

Use a glass, or glazed earthenware jar, to prepare the shellac. Put in the required amount of gum, and pour in sufficient grain alcohol to cover the gum, and you will find that the resulting mixture will be about right for general use—a little too heavy for fine, light work, which is easily corrected by the addition of a little more alcohol, and heavy enough for large surfaces.

Shellac varnish should be fresh and always kept in a glazed vessel. Don't use oxalic acid to clear a pot of old varnish, so old that it won't dry hard. You had better empty your can into the garbage barrel and fill up with varnish so fresh that it will not need the oxalic acid to make a respectable-looking job. In short, you can add nothing to the varnish, made as above, which will improve it.

The advantage in price induces many firms to use some one of the many grades of wood alcohol now to be had, and also the prices *and* quality are so graded that almost everybody can satisfy the patternmaker, the moulder, *and* their own conscience, if they don't expect too much for their money and have gotten the patternmakers and moulders thoroughly subdued. The saving in price will make a good showing on the books of the purchasing agent, but will cause the moulder's hair to turn gray, and make the patternmaker wish that he had been born Depfeller, with a Rockbilt conscience.

There are many patterns made for a single casting only for which some of the cheaper varnishes are, perhaps, good enough; still, the apparent saving in price is always reduced by the extra labor cost of applying and rubbing down. This increased labor cost will follow the pattern all through its usefulness; moulders will shun its society, and, if the varnish is mixed with wood alcohol, the patternmaker will suffer, for it is well known that all wood patternmakers subsist almost entirely upon the alcohol furnished by the firm to dilute the varnish, and they dare not drink pyroxylic spirit.

While the shellac varnish in its natural color gives the best of results, it is sometimes thought advisable to color it. Black, the most common color, is produced by the addition of lampblack; red is *best* made by the use of Chinese vermilion, and blue of an indifferent quality may be produced with Prussian blue. It is unnecessary to state that all of the coloring matter used should be dry and very finely pulverized.

In mixing colored varnish, add the coloring matter to a small quantity of varnish and mix thoroughly to a smooth paste, then add varnish, and alcohol if necessary, until the mixture is of the consistency necessary to spread and cover nicely. It requires some experience to produce both color and gloss, which are always the ocular proof of a good surface.

In spreading shellac varnish, don't think that you can produce a good surface on a rough pattern by covering it with two or three coats of varnish. You will find that the varnish makes the unevenness of the original surface more and more apparent, and that the only way to produce that flat, glossy surface dear to the heart of every real patternmaker is to first make the surface of the pattern flat, and then produce the gloss by the judicious use of the shellac, alternating with light doses of sandpaper.

In the case of hollow patterns and core-boxes, it is a good plan to cover the entire surface, both inside and outside, with shellac. If there is time, the inside of pattern and the outside of core-box might have one or two coats of good oil paint, which will wear longer than shellac, but, unfortunately, does not dry quickly; neither will it produce the glossy surface given by shellac.

CHAPTER III.

MISCELLANEOUS MATERIALS.

HAVING considered the two principal elements of all patterns—lumber and varnish—let us turn our attention to the other necessary materials. Of these, glue is probably the most important. There are many kinds of good glue in the market suitable for pattern work. For a large shop, employing many patternmakers, where there is likely to be some one specially appointed to the preparation and care of all of the glue pots, any form of glue, of good quality, will probably give satisfaction, as the personal responsibility of the glue-maker will eliminate the two most common defects: burned glue, and sour, or rotten, glue.

For the small shop, or the shop which uses but little glue, I would recommend the pulverized form, because it can be very quickly prepared for use, thus making it possible to always have sweet, strong glue ready for any job.

Don't put anything on the joints that will prevent the glue from soaking into the pores of the wood.

If you wish to make joints that will hold strongly, they should be nicely fitted; don't expect glue to hold two pieces together unless they are actually in contact. While it is possible to fill up large cavities between the pieces to be joined (if you have enough glue), when the glue dries it will ether distort the pattern by drawing the parts closer together, or, failing to do this, will give way through the cavity which was filled with liquid glue, leaving the joints disconnected except at such points as were actually in contact before the glue was applied.

As to the consistency of glue when applied, I would remind you that the holding property depends entirely upon the ability of the glue to enter the pores of the wood, or other material. Thus glue mixed very thick, which might take a very strong hold on material with large pores, like white pine, would be almost useless for wood having a dense surface, like mahogany or cherry, as the glue would "chill" before "taking hold," which means that it would not be absorbed into the pores of the wood. This can be partly remedied by heat, as the heat liquefies the glue, giving more time for absorption.

After absorption, the strength of the joint depends upon the quality of the glue, not upon the quantity used; for while it is best to use plenty of glue, it will readily be seen that when the joint is forced together, bringing the surfaces actually into contact, there can be left only such an amount as has entered into the pores of the wood.

Beeswax is another very necessary material in pattern work, as it has qualities which render it almost indispensable. It is very easily worked and hardens almost immediately. It may be used in the pure state and worked cold, although it had better be worked hot, or at least warm. If it is thought desirable to have a harder material, melt beeswax and resin together, adding a little beef tallow to prevent the mixture from sticking to the slicking tools.

Beeswax which has been adulterated with tallow or paraffin wax is poor stuff for pattern work, as it does not adhere to the wood readily.

A mixture of beeswax and tallow is sometimes applied to the surface of iron patterns, the patterns being first made hot enough to melt the mixture; but as iron has a surface which, if kept clean and free from rust, is good enough for patterns, I have found that bayberry tallow alone, applied to a hot pattern, answers the purpose just as well, and is much easier to use.

Painter's putty is often used to fill nail holes and for fillets. If given sufficient time to dry thoroughly it adheres strongly to both wood and metal, and were it not for the time required it would easily force beeswax entirely out of use on wood patterns.

Paraffin wax has always been used for finishing metal patterns and core boxes. As it stands the application of water I use it alone for core-boxes, which require frequent washings. It is essential that the boxes, after being treated with the paraffin, should be thoroughly wiped out, else a gummy substance is left upon the surface which will cause the core-maker to use language and lose time and temper.

Paraffin is also used to treat wood which is to be used in mounting patterns for, or on, moulding-machines. The wood, after treatment, being impervious to moisture, makes what is otherwise an almost impossible material very useful for this purpose.

A sheet-iron tank large enough entirely to immerse the pieces to be treated, and containing a steam coil to melt the wax and keep the temperature as high as is possible without danger of firing the wax, will be necessary for the process. White pine will require from ten to twenty-four hours to become thoroughly impregnated, which condition may be known by the sinking of the piece in the liquid wax. Pine absorbs from forty to sixty per cent of its own weight of paraffin.

Sandpaper, used intelligently, is a very necessary tool (?) to the patternmaker. If used *before* edged tools, it is rather a hindrance than a help. It requires quite a little care and some skill in using this tool to produce good results, said good results being improvement of surface while preserving the necessary angles and high places on the pattern.

In some cases this final improvement, or *grading*, of the surface is delayed until one or two coats of varnish have been applied. This method, while it gives the pattern a piebald appearance, which some might think an improvement, never increases its usefulness.

After varnishing, don't sandpaper until the varnish has thoroughly dried, and then only enough to cut off the raised "grain" of the wood. After the first coat of varnish and rubbing down, use no new, sharp sandpaper. (This is the only time and place where a dull tool is better than a sharp one.) If you have no partly-used-up sandpaper, *dull* some by rubbing two pieces together and then putting a few drops of oil on its surface or giving it a rub over your lump of wax.

CHAPTER IV.

THE BENCH AND ITS ATTACHMENTS.

THE bench is a very important part of the pattern-shop equipment, as there must always be *some* bench work in making wood patterns. The size, style, and position of the bench must be in accordance with the character of the work to be done.

The length, for nearly all classes of work, may be limited to eight feet, especially if the patternmaker has free access to both ends of his bench without interfering with his neighbors.

The height cannot be arbitrarily fixed, as each man can best determine his individual needs in this respect, and, within limits, he should always be allowed to do this.

The width of top surface should be from 28″ to 32″; too great width is a common mistake, and while it furnishes storage room for nails, screws, and various other small accessories, it is always a mistake. The bench surface is not profitably used for storage purposes, and the presence of unnecessary articles gives an untidy appearance which it is well to avoid.

This too prevalent accumulation of unnecessary articles, such as bits of wood, broken packages of screws and nails, discarded parts of patterns, and many other things which are often entirely useless even to the one who has so carefully hoarded them, favors the accumulation of the patternmaker's enemy, dust.

We patternmakers are, perhaps, more prone to the hoarding habit than other tradesmen, as is witnessed by the joy with which we hail the coming of the new hand with his large, fat tool-chest, which promises many new and curious tools, often more curious than useful. The fortunate (?) possessor of a large collection of "curios" is constantly finding new things in his collection—new because he had forgotten their presence, which fact will show how very useful he has found them.

I am pleased to note the trend toward smaller and more compact tool-chests or closets. There being no room for articles which are curious only, they are not present to occupy valuable space, accumulate dirt, and create untidy habits.

The front of top surface of bench should be from two to three inches thick and about sixteen inches wide, and this front plank should be somewhat higher than the remaining surface in order that it may be surfaced off as often as may be found necessary to preserve the flat, true surface so essential for many portions of the work.

To many patternmakers drawers under the bench are useful, and help not only the progress of the work by offering a convenient and accessible storage for such articles as wax, nails, sandpaper, and other necessary materials, but they also protect these articles from dust (if they are kept closed), and thus tend toward general tidiness.

There is a class of patternmakers to whom drawer space means only a place for the reception of such articles as they have no further use for; and for these men they usually contain a collection of broken and worn-out tools, dirty and discarded aprons, spoiled parts of patterns, and occasionally an article of some value which has been mislaid.

The bench should be provided with a good bench-hook, adjustable as to height and capable of being forced down even with the surface of the bench. The holding edges should be kept smooth, reasonably sharp, and always at the extreme top. To accomplish this last desirable effect, the hook may be fitted with its top inclined slightly toward the upper end of bench. This leaves the rear edge, which is to do the holding, higher than any other portion of the top.

Another very necessary part of the patternmaker's bench is the vise. Many of the vises offered to the patternmaker are too small and flimsy to be of any real use. Don't be afraid of a *large* vise, one with big, flat jaws that may be opened sixteen inches or more. This vise will hold small pieces just as surely and carefully as the small vise, but the small vise cannot be made to successfully hold large, heavy pieces.

If the vise has a swivel jaw so much the better, as the same adjustment which renders the vise capable of gripping tapered pieces may be used to give the vise a firm hold of parallel stock or work which from its shape can only be entered into one end of the vise.

A table about four feet long, two feet wide, and from twenty-six to thirty inches high is a very useful adjunct to the bench for most classes of work, affording the patternmaker a convenient surface on which to assemble the parts of his pattern, thus keeping the bench clear for working out the parts.

And finally, but not lastly, there should be provided a stool for each man. This, I am sorry to say, is not always considered essential or even advisable. The conscientious workman would probably stand all day in a shop that didn't furnish stools, while the "soldier" would be found seated upon his chest, or even upon the bench itself, without, perhaps, a word of disapproval from the foreman. This, however, proves nothing, as all patternmakers are not "soldiers," nor would they be if provided with suitable stools.

CHAPTER V.

HAND TOOLS.

THIS portion of the patternmaker's outfit is less numerous and less bulky than in the past, when a first-class patternmaker required one or two tool-chests about the size of the modern seaside cottage to hold his belongings. In those days the firm furnished nothing but the bare materials (sometimes very little of them), and no machine tools; the patternmaker was even expected to furnish his own hand-screws, or get along without them.

The old-fashioned hand tools, with the wooden stocks, are, in the modern, up-to-date shop, replaced in a great measure by the machine tools, with their many and ingenious attachments; and such hand tools as are still found necessary are principally of metal, thus doing away to a great extent with the wood stocks and frames, which required a great deal of care and were, at their best, unreliable where great accuracy and precision were called for.

The hand tools of to-day also differ in kind, there being a greater demand for, and consequently a greater variety of, tools for measuring, laying out, and testing the various parts of the work; the actual removal of the surplus stock being accomplished by machines that are competent to perform, expeditiously and with accuracy, many operations which in the past could only have been intrusted to, or attempted by, the most skilful of workmen, and at the expense of much time and individual energy.

The caring for bench-planes to-day, with their accurate metal stocks and thin steel cutters, requires but a fraction of the time formerly used in keeping the old-style wooden-stock plane, with its heavy steel-faced "iron," in good condition.

The patternmaker of to-day may procure, at small cost, cutting tools of a quality formerly unobtainable, or, at best, only to be obtained at a price which was far beyond the means of the average workman.

The skill of some men in the use of edged tools seems, to such of us as always find difficulty in making these tools do efficient work, to be an inherent quality of the individual, something not to be attained by mere application. This is largely a wrong conclusion, and it is usually found that the apparently greater skill of this much-envied individual is really the result of using *sharp* tools, supplemented by care in the selection and placing of the pieces of wood used in building up the pattern, which he finally cuts and carves into shape with such seeming ease. Sharp tools will not cure awkwardness, but they will always make it less apparent.

In order to have sharp tools, the first requisite is a good oil-stone, one that will quickly put a smooth, keen edge on a tool. Here, again, the condition in which this indispensable article is kept may be such as to seriously affect its usefulness, a poor stone, well kept, giving better results than a good stone in poor condition. The stone should be kept clean, and with its surface flat and true; then it is always ready to do good work, and you will probably find that you have got one of the best, if not *the* best stone in existence. Well, take good care of it, and you may thus prolong its efficiency.

In purchasing tools, always look for quality rather than quantity, as you will be able to do more and better work with a few really good tools than with any number of poor ones. Having gotten your good tools, including *the* oilstone, take good care of them, and don't be afraid to put them to work. Tools that are too good to use for ordinary, every-day work should find no place in the patternmaker's "kit"; and even *good* tools can usually be replaced by better ones, so don't be afraid that too much personal effort on your part is going to cause a scarcity of good tools.

If you wish to become the fortunate possessor of a really good "kit," buy only according to your needs, not in "sets," per some toolmaker's catalogue. These "sets" are made up of two classes of units, the useful and the ornamental. While useful tools may also be ornamental, it is the useful quality which "pays the rent" of the owner.

When you say that an edge-tool is "sharp," you mean that it has an edge (see Webster's Unabridged) of such thickness, or thinness, as will most readily cut the material being worked. Thus the condition called "sharp" is a relative condition of thickness or angle, fixed by the quality of the tool, the material to be worked or cut, and *the* oilstone. A tool ground at such an angle as has been found best for cutting steel would be of little use in working pine; and while the tool which cuts pine smoothly might be of such a quality of steel as would cut metal, the thin edge which makes the tool most efficient for pine would soon be destroyed by the metal.

I shall attempt to give no rules for grinding edge-tools, as the proper or most efficient angle can only be fixed by the material to be worked and the quality of the tool. An edge which cuts pine with ease and persistency may be quickly destroyed if the tool is applied to some harder wood, such as mahogany or cherry. This destruction is caused by the breaking or crumbling of the edge, the greater resistance of the mahogany causing the edge to spring and break off. After one or two applications to the oil-stone this tendency is corrected, and we say that we have now got the tool "down to an edge," or that "the edge stands up" now. What really happens is a thickening of the edge, caused by application to the oil-stone.

Continued rubbing on the oil-stone makes the edge so thick that we are, at times, obliged to resort to the grinder, or perhaps you still cling to the old grindstone, which has been, and still is, a real help to the wood-worker, but is not an indispensable tool, as the wet tool-grinder more than fills its place.

CHAPTER VI.

BENCH WORK.

Bench work, or the use of hand tools in reducing pattern stock to finished patterns, is to-day largely a question of facilities. The shop which is obliged to do, or allows to be done, too much of this sort of hand work, will find itself handicapped by the cost of its pattern work. Still there must always be some of this kind of work.

In the old days, when the patternmaker was expected to do the whole job, except, possibly, the actual chopping down of the tree, with his own hands, assisted only by the tools he had been able to acquire personally, bench work was the beginning and the end and all the way between—in fact, pattern work was all bench work.

To-day, with the bulk of the work accomplished by the machine tools, bench work has come to consist principally of laying out the different pieces required in building up a job, and, later on, of assembling the same into the finished pattern. This is duly attested by the decreasing number of cutting tools for hand use, and the greater number of measuring or "laying out" tools, such as scales, squares, bevels, angles, dividers, calipers, and the like. Note also the improvement in these tools both as regards their accuracy and their convenient forms.

The shooting-board has been replaced by the trimmer; the bench planes by the hand jointer; the hand-saws by the circular saw, and the whip-saw and draw-knife by the band-saw. In short, the bench work, in some of the present up-to-date shops, consists principally of the preparation and sharpening of tools and cutters for the machines.

The tendency of the times toward specialization is seen in some pattern shops, where one man does all of the band-sawing, another the lathe work, while a third man runs the buzz-saw and still another has charge of the planers. This division of labor may result in making the bench-workers a class by themselves; when it does, they will easily be at the top of the list, as the laying out and the final assemblage of the parts must necessarily fall to them.

Another very important part of bench work is the translation of the scale drawings, usually furnished to the patternmaker, into full, pattern-size lay-outs, showing the actual shape and size of the patterns required, thus enabling the patternmaker to cut his material to the best advantage and with as little waste as possible.

Thus bench work, or that part of it which is accomplished by hand cutting tools, has been reduced from the complete job to such parts as are of irregular shape and thus require cutting and carving to shape by hand. Patternmakers may come to be classed as "lathe-hands," "sawyers," and "bench-hands," but as most shops do not employ a sufficiently large number of patternmakers to make the employment of these specialists profitable, there will always be a large percentage of good, all-round workmen.

CHAPTER VII.

MACHINE TOOLS FOR PATTERNMAKERS.

PATTERNMAKING, like the machinist's trade, is getting to be simply a question of a man's ability to manage the machines which do the actual work. A pattern shop fitted up with improved wood-working machines gets along without much hand work other than what may be necessary in putting the work together. It is possible to keep machine tools, not only the lathe, but the circular saw and the planer, in such shape that work may be cut right down to the line, although there are some things to be considered beforehand. By the way, why is it that the pattern shop, with all its high-speed machinery, is located at the top of the building? This is usually the case, although I know of one shop that is located on the ground floor, and another that is now at the top of a three-story building, but used to be located under the foundry.

High-speed machines need a solid foundation. A buzz planer running 4,500 revolutions a minute will soon show you if there is any spring to the floor it may stand on, especially if the driving-belt is so laced that every time the lacing runs over the pulley it has the same effect as a blow struck on the spindle. A lacing seems like a little thing; but when it is fixed in a belt, and travelling at a speed as high as 4,500 feet in a minute, it becomes a factor which must be considered if you wish to get the best results from the machine.

Did you ever notice the difference between a machine whose driving-belt was strained up like a fiddle-string, with the lacing so prominent that you could hear it all over the room every time it goes over the pulley, and a machine whose driving-belt was just tight enough to do the work well, with the lacing or fastening so made that it makes no noise as it passes over the pulley? The first machine will get hot, do poor work, and will impress any one not used to it with an uneasy feeling, as if something was wrong; while the second machine will run all day as cool as a cucumber; and the man running it can do more and better work because he knows that the machine is all right, and therefore he can give his whole attention to the work.

This belt question I consider of more importance than is usually allowed for in practice. In many cases, the cure-all for a machine that is not working right is to take a little out of the belt. This is sometimes like giving a tired horse the whip when it's oats he wants; or, to make my meaning plainer, be sure that your horse, or machine, is in good running order before putting on the whip. With the machine in good order, and the belts properly arranged, they need never be tight enough to cause any trouble about heating the boxes, or in making the spindle they may drive jump so that you can hear it and feel it, and also see it on the work. This jumping is generally owing to the unevenness of the surface of driving-belt; often it is caused by a lacing badly put in, which makes a lump on the inner surface of belt, and pounds on the pulley every time it passes over the latter. This we can remedy by using an endless belt, or some form of lacing that will make a smooth joint and thus imitate an endless belt, the great virtue of which lies in the fact that it has no joints and, therefore, will run perfectly smooth. It may still be too tight and make the journals get hot. This can only be cured by judgment and skill in the care and management of the machine.

An excellent way of lacing a driving-belt for a high-speed machine is to hold the ends together and sew them with tough, strong wire, making the stitches as short as possible. This is the best thing I ever saw for a lacing in a fast-running belt.

CHAPTER VIII.

THE BAND-SAW.

A VERY useful tool in a pattern shop is a good band-saw. The more it is used the better it is liked, and one is continually being surprised by its capabilities. It will do nearly everything that a circular saw can do, and a great many things that can't be done by a circular saw. The band-saw, if kept in good order, will do nice work, but if the guides are allowed to get worn out of shape, leaving the edge of saw loose, the saw so badly set and filed that each and every tooth strikes in in a new place on the stuff being sawed, and then the hole through the table so large that you can stick your finger down through the table all around the saw, it won't be likely to do very nice work, and it wouldn't be safe to get very close to the line in sawing, because you never would be sure of where the saw was cutting on the bottom side of the stuff. With a saw that is set and filed accurately you may safely cut right up to the line, when necessary, if you don't crowd the saw but allow it time to cut free and clean.

In sawing short curves it is very easy to cramp the saw by feeding too fast or in the wrong direction. It is hard to give any explicit directions in regard to feeding when sawing curves, but let the feeding be so done that all the power exerted will tend to force the saw against the collar or plate behind it. You shouldn't twist the stuff so that the saw is pressed hard against the sides of the guide, as this causes great friction and consequently throws a great strain on the saw, also heating it. If you persist in doing this you will break a great many saws, besides wearing out the guides very fast. The rubber covering on the wheels will also come in for an excessive amount of wear.

When the saw needs setting or filing, before you take it off the wheels brush the dirt and gum out of the teeth. A file card does this first rate; then joint the saw with an emery stone, taking care to hold the stone square across the saw. Take off the saw and, if it needs setting, set it just as little as possible. Don't try to make a wide saw do the work for which you should use a narrow saw by setting it very wide, for it won't work nice, and it is hard on the wheel covering. In filing, it is customary to file all from one side and square across, although the saw would cut better if filed partly from each side.

After the saw is replaced on the wheels, the guides are adjusted to the saw, not the saw made to run in the guides, just as they are, because it ran so before filing; unless both the top and bottom guides are just right to fit and hold the saw. Make sure that they are just right. They should be exactly in line with the saw, and take in the whole width of saw except the teeth. Then adjust the upper wheel. This will usually have to be done whenever the saw is changed, and sometimes when a saw has been newly set. The wheel is usually, and I presume always, provided with means for tilting it over toward the front or back as may be necessary, so that the saw won't run off. It should run against the back of the guide very lightly when not doing any work.

This saves the guides and also prevents any unnecessary heating of the saw.

Now joint off both sides of the saw in this way: use an emery stone having a flat surface, then holding the stone against the side of saw touching the back edge first, and keeping it in contact with the back edge, swing it around until it touches the sides of the teeth. This method will prevent any possibility of cutting off the front corners of teeth, and therefore the saw will cut to its full width.

The saw should run straight and true when in motion and not squirm around like a snake, as I have seen some do. You can perhaps imagine how close to the line it would be advisable to get with a saw that runs back and forth sideways, three or four times in each revolution. Of course this sidewise motion should be controlled by the guides, but the same saw that has the most need of the controlling influence of the guides doesn't get it because the guides are in no better shape than the saw itself.

A saw that has been broken and mended a number of times is very apt to run crooked, not only on account of the joints, but because the soft places which the brazing of the joints make are very apt to get bent. When your saw gets broken and you wish to mend it, begin by filing down the ends you wish to join. Make the joint from ½″ to 1″ long, taking care to file the ends to a straight taper, so that the joint will fit closely together without springing and also be of the same thickness as the rest of the saw. This is important, as you will find that if you have to spring the joint together when you braze it, you will spring the saw on each side of the joint. Then when you are ready to braze the joint, take care to clamp it down straight, and don't get more thickness of brass, silver, or whatever solder you use than there will be of steel after the joint is finished. Put the saw on the machine, adjust the guides, and try it. If the edge runs in a straight line, and the new joint passes the guide without being heard, you have done a good job, and you will be repaid for all your trouble by the quality of work turned off.

If I should try to tell all that might be done by a band-saw I should wear out the patience of the reader, and perhaps not tell him anything new after all. The best job I ever heard of as being accomplished on a band-saw was the sawing of gear-teeth, right to the line, so that they only required sandpapering to complete them. I didn't see the gear-teeth, but I always thought they must have been finished before the sandpaper touched them. Seriously, about the only thing in the line of sawing that can't be done on a band-saw is making holes. This is where the band-saw has to yield to the jig-saw, its older relative. This machine (the jig-saw) as in use in most shops, makes more noise than all the rest of the machinery together, and does comparatively little work. It is just the opposite with the band-saw, which makes very little noise but does a great deal of work.

There are, of course, some exceptions to the kind of jig-saw noted, but even the best of them require constant care and a good deal of it. The saw wants filing very often, and why shouldn't it when you remember that about five inches of its length does all the work, and consequently gets dull very quickly. Then the guides for the crossheads —perhaps there are two crossheads—must be kept snug, and the connecting-rod or pitman mustn't be allowed to get loose; and there is usually trouble in keeping the machine oiled, as the sawdust, more or less of it (generally more), falls directly on the crosshead and pitman, and soon absorbs the oil from these parts and from the guides. But we put up with them with all their faults, because we can't saw holes with a band-saw, until some genius (?) makes a band-saw with a joint in it.

One great difficulty in the way of a smooth-running jig-saw is a little too much speed; they run too fast. If the pitman and crosshead are too heavy and are not well balanced, you can easily see what a little too much speed will do. Then there are jig-saws that are not provided with any appliance to ease the shock of reversing the motion at the end of stroke. The spring commonly used at the top to strain the saw helps the reversing at the lower end of stroke, but hinders it at the upper end. Another point where the jig-saw has the advantage of band-saw is in the size of work which may be done. On the band-saw the size is limited to the diameter of the wheels which carry the saw, but with the jig-saw the only limit to size of stuff sawed is the size of the room where the saw is located.

A good jig-saw should have its crosshead and pitman as light as is consistent with the necessary strength, and well balanced, with a good tension for saw at the top end. This is a sure method of holding the saw, and one that can be operated quickly. The pitman must not be too short; neither should it be too long, as this will add unnecessary weight to the reciprocating parts. Not less than three, or more than five times the length of stroke will put the length within reasonable limits. The tension-spring helps the reversing at lower end of stroke. Then if the blower for removing the sawdust could be located at the top end of stroke; but the difficulty in the way of this is the pipe necessary to convey the compressed air from the blower to the upper surface of work. Still an air cushion might be utilized to keep the sawdust off the crosshead and guides, and it would certainly make the saw run more steadily. Then, to bring out the good points, and make them show to the best advantage, the saw should stand on a good foundation.

It is not a good plan to use much oil on the saw, or the saw-guides, because the sawdust sticks to it, and the oil gets on your work, and it makes things dirty and disagreeable. This applies equally well to the band-saw. It is much better to keep the saw in such good order that it will need no oiling at these points.

I recollect reading in the *American Machinist* about the influence which poor tools, dirty machines, and the poor work resulting therefrom, had upon the character of the workman. Where these things are chronic, the man's work will soon become, like the shop, poor and dirty, and who ever saw a dirty machine do a good job?

Take, for example, a band-saw that hasn't had the oil and dirt wiped off in six months, and this, too, where it has been the rule to oil the saw and saw-guide as often as any one thought necessary. The oil will collect all the sawdust that will stick to it; the more oil, the more sawdust. The saw itself I should expect to find in keeping with the machine, every tooth set to a different width, and filed to a length of its own. This saw won't do good work, and the man who has the care of it won't be apt to lose much sleep on this account.

CHAPTER IX.

THE CIRCULAR SAW.

I THINK that the circular saw will rank first among machine tools for the patternmaker. A great variety of work may be done with a sharp saw that is mounted on a good table.

In using a circular saw, the first thing to attend to, after we know that the belts are all right, is to see that the saw itself is in good order. Now, I am not going to give any rules for sharpening saws, but will just say what has been my experience. It would, in fact, be rather difficult to make any fixed rule in regard to setting and filing saws without first knowing just what they were to be used for.

For pattern work, a saw needs to be kept sharp, jointed true, but as the lumber is dry and soft it won't need much setting. A saw may fill these two first conditions and still not do a good job, because of the way in which the saw has been set and filed. It may have been set unevenly, or when the teeth were not all of a length. The saw should be jointed before removing from the arbor.

If you use any kind of a set that slips over the teeth until a gauge touches the point of tooth, you can see the object of jointing the saw before setting. It isn't necessary to set the saw every time we file it, and for this reason we should be particular, when it is necessary, to set the teeth all just alike, and as the point of the tooth is usually the guide in setting the saw, it is evident that the points should all be at the same distance from the centre of arbor. This is accomplished by jointing the saw while it is running in position.

As to the filing, I have found that a splitting saw, if filed as near square across the saw as possible, gives the best results. It cuts more freely, leaves the stuff smoother, and will keep sharp as long as a saw which is filed at an angle or fleaming.

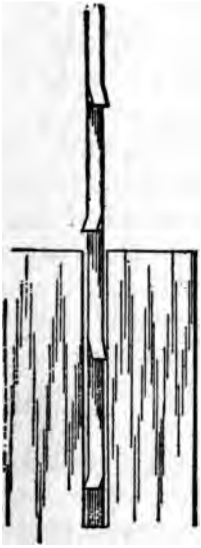

FIG. 1.

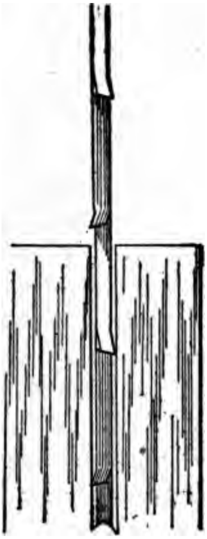

FIG. 2.

If you believe in filing the teeth at an angle with the axis of saw, let me show you something which perhaps you have already noticed and can explain to your own satisfaction. After you have sharpened your saw take a piece of lumber and try it. After cutting in a little way, stop and see the shape of the end of kerf. The points of the teeth have cut ahead and left the wood in the middle of kerf projecting back toward the saw. What cuts away the wood that forms this point? It must of course be removed by whatever edge the tooth may have crosswise of the saw.

With the saw filed as in Fig. 2 (which also shows the point of wood left at the end of kerf), there cannot be a very thin edge, and consequently it won't be an edge that will cut wood; and as it will require some crowding to make it tear or bruise off the wood, won't the crowding tend to force the points of the teeth away from the centre of the cut, making the saw cut a wider kerf than it should, and checking the speed until it runs slowly enough for each tooth to be heard as it enters and leaves the wood? Then the saw will rattle, until it has cleared for itself a little wider channel. At the same time you will stop crowding the piece of stuff, and the saw will have a chance to regain its speed, when it will run on again for a little space, the distance or time between two of these spells being governed by the kind of lumber, keenness of the saw, and the amount of force used in pushing the stuff up to the saw.

Is this the way you have explained it to yourself? I claim that the cutting edge of the teeth on a splitting saw should be as nearly as possible at right angles with the grain of the wood operated upon. This is accomplished by filing the saw square across, both the front and top of tooth, as in Fig. 1, which leaves every tooth with an edge or point like the edge of a chisel. What sort of progress would a man make in beating mortices with a mallet and chisel if he continually left the ends or heads in the shape of the end of kerf in Fig. 2? Doesn't he get along best when he places the edge of his chisel square across the grain? Of course he does, and so will a splitting saw cut the best when the teeth cut like chisels and strike the wood square across the grain.

For a cross-cut saw the points of the teeth should resemble the point of a knife, so as to cut off the wood at each side of the "kerf." The centre of the kerf will take care of itself now.

You will find that a splitting saw filed square across, in going through a piece of stuff cuts away the wood in the form of shavings, not sawdust, and it will also require less crowding and will cut cleaner and smoother. In short, it is the right way to file a splitting saw. But I am afraid that I have set down a rule, and a very arbitrary rule, for filing splitting saws. Well, try it, and see for yourself.

Don't let your saw get worn off on the sides of teeth, because then it won't cut, but will bruise or tear the wood. A saw which cuts nothing but dry pine won't get this way, and a saw which is kept sharp won't, either.

I have seen a saw-table, made of seven-eighths matched spruce, with the hole where the saw came through so large that it wouldn't be safe to saw anything less than a foot square, for fear that it would fall through the hole, but this wasn't a table for nice work, as any one could see. I remember another saw-table, also made of wood, where I sawed some curly maple veneers $6\frac{1}{2}''$ wide and only $\frac{1}{16}''$ thick, with an ordinary 16″ or 18″ saw, and they didn't go down through the table either. This saw, which I am pretty sure was filed square across, was located in Colt's armory pattern shop, at Hartford, Conn., and with other saws for the same table, were the best cutting saws I ever used.

The iron saw-table of to-day is a marvel of convenience, compactness, and durability, and with the different attachments will do a great variety of work, and do it nicely.

Did you ever have any trouble in setting the fence or guide on an old-fashioned (and some new-fashioned) saw-table to saw to an exact width? After measuring closely the distance between saw and fence, you turn down the clamp-screw and move the fence forward or back a little. Try it again and this time hold on to the fence. There, now, it is all right, sure you have got it clamped tight. You try it and find that it isn't tight, and give the screw another turn, with the same result as in the first trial. By this time you are getting tired, and long for a chance to get even with that fence. Then you took a hammer, and tried, by rapping it lightly, to correct the error, but it didn't move readily, and you got excited over it; perhaps you broke something.

How much better the fence on the iron table works, especially those having a quick and slow motion. Make a gauge line on a piece of stuff just where you want the inside of saw to cut. Set the fence by the quick motion nearly to this line, start the saw, and by the slow motion move the fence up until the saw splits the line. Your success will now depend upon the steadiness with which the saw runs and your skill in feeding the stuff up to the saw.

Another bad feature about a wooden table is the wear. The fence gets rounding and out of square, the table wears down into a hollow, which is lowest just in front of saw, and the hole where the saw comes through the table will wear off on each side of the saw, especially the top corners. This leaves it in a bad state for doing any small work. To offset this, the iron table is a little apt to be sticky like an iron plane, and does not keep as clean as a good hardwood table.

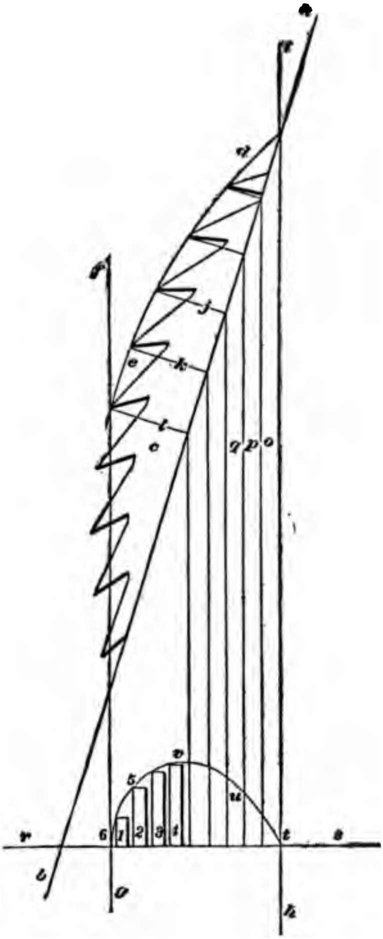

FIG. 3.

Fig. 3 will illustrate two ways of roughing out small core-boxes on the buzz saw. I have heard it asserted that it was possible to cut a small core-box for a straight round core exactly to the finished size, but I will show you why this can't be done, by referring to Fig. 3.

Suppose we wish to saw a box the diameter of which is equal to the space between lines *f g* and *i h*. Let the line *a b* be the top of saw-table; set the saw to the right height, or one-half the diameter of the core-box. A part of the saw, represented by the arc *d e*, is now above the saw-table. We must now find the angle at which the box must be passed over the table, that the saw, which has been adjusted to the correct height, may also be made to cut to the right width. It is evident that a line representing the chord of an arc *d e* made by the points of teeth on saw, which chord will be at the surface of table, when drawn on the core-box, if placed in such a position that one end touches line *i h*, while the other end touches line *f g*, will show the angle at which the box must pass over the saw.

When the angle is small, as in the present case, allowance should be made for the thickness of saw.

Now by making a diagram similar to Fig. 3, we will be able to see just what shape the core box will be in after passing over the saw. Draw lines *j k l* from *a b*, the top of table, to an arc of circle *d e*, and perpendicular to *a b*, then from the points between these lines meet with *a b* draw other lines *o p q* at the same angle with *a b*, that we found would be necessary to make the saw cut to the right width; draw a line *r s* at right-angles with *o p q;* this line will represent the face or joint of core-box. Now measure on lines *j k l* the distance between *a b* and arc *d e*, transfer each of these spaces to lines *o p q*, measuring this time from line *r s* and keeping the spaces the same on similar lines; that is, make the space on line *q* the same, measuring from *r s*, as the space between *a b* and *d e* measured on line *j*. After transferring all the spaces in the same way, connect the points found on lines, *o p q*, and the result will be a curved line *t u v*. I have shown only a part of the whole curve, but enough is shown to enable you to see that a section of the box, instead of being a true circle, would vary therefrom in proportion as the diameter of saw varies from the diameter of core-box. The nearer the two are of the same diameter the closer we shall be able to cut the box. If it were possible to use one-half of the whole saw, and move the box exactly square across the saw, we should be able to cut out a half-circle having the same radius as the saw, but this would not be possible with the ordinary saw-table, therefore it isn't likely that any one will cut round core boxes exactly to the line in this manner.

Staves may be hollowed out in this way very nicely and rapidly. For this purpose you want a keen saw, and one that is very stiff.

A better way of roughing out core-boxes is also shown in Fig. 3, where *v*, 5, 6 is the circle of box and 1, 2, 3, 4 show grooves sawn lengthwise through the box, and of such depth as will just reach the line *v*, 5, 6. I have shown thin strips of wood left between the saw-kerfs, but the cuts

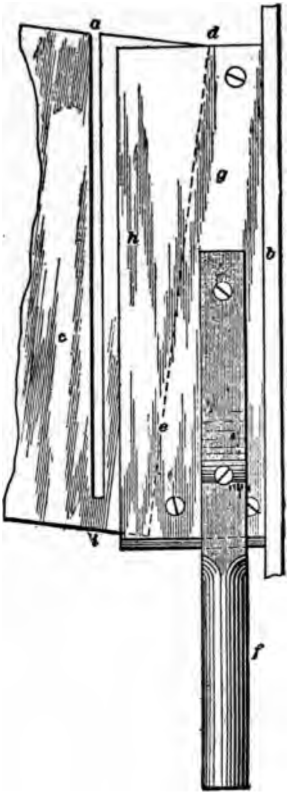

FIG. 4.

may be made close together or even overlapping near the sides of box so as to remove more of the wood shown above groove marked 1.

Fig. 4 shows a very common way of sawing wedges. The gauge is made with one side shown by dotted line having the required taper. Place the opposite side against the fence *b*, hold one edge of the piece to be cut against the templet, letting the end toward you rest against the shoulder formed by the piece *i*, which is fastened to the back end of templet, then by moving the stuff over the saw while it is held against the templet, which in turn is guided by the fence, you will be able to saw any number of wedges all alike, and having the same taper as templet *g*. You may facilitate matters a little by putting a handle on the templet as shown at *f*, and by making the templet of the same thickness as the stuff to be sawed, and putting a piece on top, as shown by *h*, reaching nearly to the saw, you will prevent any piece being caught and thrown back by the saw.

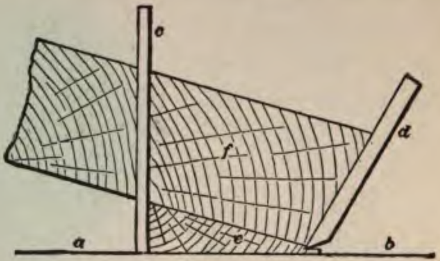

FIG. 5.

If you wish to cut the wedges to a point, reverse the templet and put the handle and the piece *i* at the opposite end.

Fig. 5 shows a way of sawing up staves which wastes no lumber. *a b* is the top of table, *c* is the saw, and *e* the templet or gauge piece used. This piece is made with the angle at upper corner next the saw, the same as the required angle for staves, and the edge under fence *d* is sawn to a parallel thickness, as shown; or you may cut a shallow groove in the upper surface of this piece, the idea being to make provision for its being held in position by the lower edge of tilting fence, which is beveled off nearly to an edge in order to keep the face close down to the table when the fence is tilted, as shown by *d* in the present case.

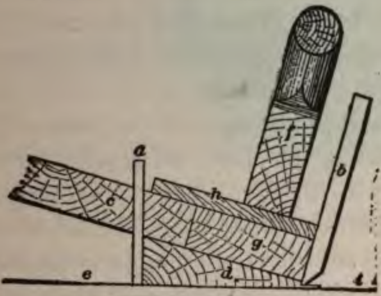

FIG. 6.

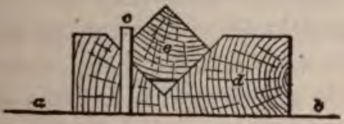

FIG. 7.

If the stuff is cut to the required length, then saw one stave off of each piece, a little wider than the finished stave, then you tilt the fence until it fits the beveled edge as shown at *d*, and move it up to the right distance from saw. Now, by turning the stuff over endwise each time a stave is cut off, you cut them all to a width and bevel both edges at one operation.

By a combination of the principles shown in Figs. 4, 5, a dovetailed wedge may be sawn as shown in Fig. 6, where *e i* is the table, *a* the saw, *b* the fence, and *c* the stuff to be cut; *d* is the beveled piece which forms the dovetail, *g* the wedge-shaped piece which gives the proper taper, *f* the handle, which is also shown in Fig. 4 at *f*, *h* is a piece put on top of *g* and projecting over the piece to be sawed—the same as *h* in Fig. 4. The stuff is to be turned over every time a wedge is cut off. Thus you see they will be cut on the right taper, and both edges beveled at one operation. The dovetails for gear-teeth may be cut in this way, or the dovetails for holding loose pieces in place.

With the aid of the tilting fence you may saw ordinary sized work so that the section shall have any form that is bounded by straight lines; but very small pieces cannot be sawed in this way, for lack of sufficient surface to steady them against the guide. In Fig. 7 I have shown a way of sawing small pieces to an octagonal form. The piece *d* has a groove cut in its upper surface, the two sides of which form an angle of 45° with the surface of saw-table *a b*. To set this in place, if the saw is raised and lowered by a screw, or in any other way that will admit of moving the saw while in motion, lower the saw below the surface of table, then place the piece *d* in its place, and fasten it in any convenient manner; then start the saw and raise it while in motion, letting it cut a passage for itself through *d*, and raising it only just high enough to cut through the stuff. You can now cut any number of pieces to the same size and shape. The piece must have a parallel thickness and one square edge.

Although I have shown the gauge *d* made to cut octagons, it is evident that the same principle may be applied to any required angle. With the gauge as shown in Fig. 7, but with the saw coming up through the centre of groove, you can cut any amount of fillets, and with the saw as shown you can saw dowel-pins, and with the help of a dowel-plate (piece of steel with a hole through it the size you wish to make pins) you can finish them ready for use, taking them as they come from the saw and driving them through dowel-plate, which will shape them ready for the pattern.

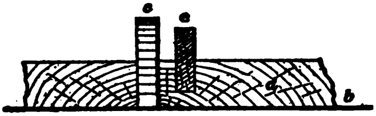

FIG. 8.

Dovetails may be cut on an ordinary saw-table if it is in good shape. Fig. 8 shows how the kind of dovetail so much used for small packing-boxes, and sometimes called Canada dovetails, may be made; *b* is the saw-table, *c* the saw, and *d* the gauge-piece. This piece is made of a parallel thickness, and before fastening to table has a slot sawn through it, and a strip of hard-wood, *e*, which just fills the kerf, is placed in it. This piece *d* must be fastened on the saw-table in such a position that the hard-wood strip *e* will be parallel with the saw, and distant from it exactly the width of cut made by saw; then the pieces left standing between the cuts will just fill the cuts on the piece used for the other half of joint. You will see that the only difficult part of the job is setting the piece *d* so that the tenon left between two cuts will be of the same width or thickness as saw kerf. Do it this way: Saw the slot in *d* for the strip *e*, fit two hard-wood strips into it, letting them project above the surface of *d* ¼″ or ⅜″, and also saw a slot in another piece of stuff before moving either saw or fence. You now have two pieces with a groove in each one at the same distance from one edge, the edge which was placed against the fence. In one of these pieces put one of the hard-wood strips, then use the other as a gauge-piece between the first one and the saw, so that it will leave exactly the same thickness between the cuts that it cuts out. After finding the width necessary, lower the saw beneath the surface of table and place the piece *d* in position against the fence. Then start the saw and raise it up slowly, letting it cut through *d*. Set it to the right height, then, after moving the fence out of the way, you are ready to go on with your job.

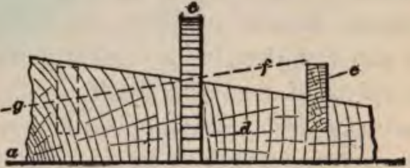

FIG. 9.

It will be found best to fasten a number of pieces together for sawing, as this will give more length to the surface in contact with the fence or strip *e*, and thus hold the stuff steady while passing over the saw.

For sawing a regular dovetail, you must make the piece *d* with the surface inclined to give the bevel necessary for dovetail as shown at *d*, Fig. 9. The hard-wood strip *e* must be fixed parallel with the saw, then you may take

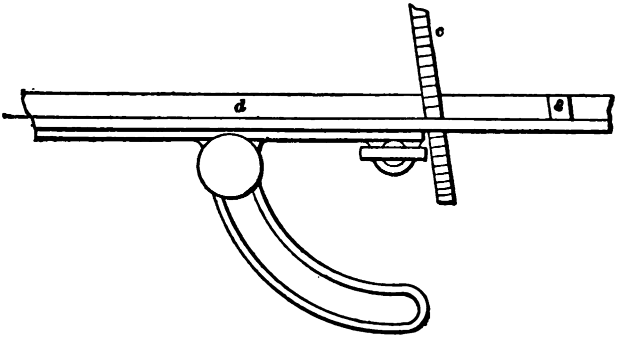

FIG. 10.

choice between two ways of gauging or spacing the dovetails. You may cut them all from one edge of the stuff by sawing one side of all the dovetails, and then by turning the gauge-piece *d* around to the position shown by dotted lines *f* and *g*, Fig. 9, being particular to place *e* at exactly the same distance from saw that it was when the first side of dovetails was cut. Then after locating the first cut from the same edge that was used in locating the opposite side of dovetails, you may finish cutting them. There is a difficulty about this which will be explained further on, and is caused by moving the gauge-strip *e* when the piece *d* is changed to the opposite side of saw.

A better way is to get the pieces out all of the same width. This may be done by the saw. Then locate the first cut on either side of dovetail by the two edges of piece, and the strip or guide *e* will do all the rest, and won't have to be moved for the second side. If it is desired to make the first nearer the edge than the distance between *e* and the saw, use a parallel piece between the stuff and *e*.

The other part of the joint, the gain or mortise, will have to be cut one piece at a time. If your saw-table has an adjustable slide for sawing horizontal angles, this may be accomplished very easily. Fasten to the slide a piece of stuff like section shown at Fig. 11, making *a* the upright portion high enough to give a good support to the stuff to be sawed, and the rabbet at *b* about the same thickness as stuff to be cut. This piece should be in length about twice the width of the pieces to be dovetailed, once the width on each side of saw, to support them as they are moved from one side toward the other. This piece is also shown at *d*, Fig. 10. The fist cut on each side of dovetail will be gauged from the edge of stuff. This can be done by putting a hand-screw on the slide at the required distance from saw. The position of this cut will locate all of the others by means of the strip *e*. The cut which holds this strip is made before fastening the piece *d* to the slide, which will insure its being parallel with the saw.

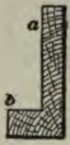

FIG. 11.

We can now saw one side of all the gains, then by turning the slide around to the opposite angle, and making another cut for *e* parallel with the saw in its present position, we can finish the gains.

If the saw-table has no adjustable slide, make a slide as shown in Fig. 12, where *a* is the fence, *bc* the slide or gauge, and *d* the saw. The two sides of the gauge *b* and *c* should have a section like Fig. 11, and should be far enough apart at the saw to give some length outside of saw to support the stuff being cut, and the distance between the saw and fence must be equal to the whole width of pieces to be dovetailed, as the fence is not to be moved while sawing the gains.

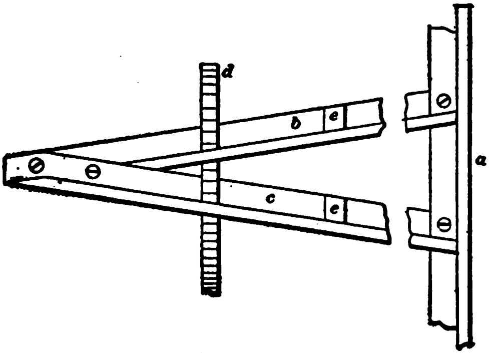

FIG. 12.

At *e*, *e* are shown the hard-wood strips which determine the space between cuts. The saw kerfs for holding these slips are made by setting the fence one space nearer the saw before locating it for cutting the gains. There is one thing which is very important, the accurate spacing of the cuts at the two angles necessary to form the two sides of gains, and which is accomplished very easily and correctly by this means. It is evident that if the spaces between the cuts for one side of the gains are longer or shorter than the spaces for the opposite side, the width of the gains will increase or diminish in the same proportion. This is a point about which great care should be taken, as it will be almost impossible to make the dovetails fit together if they are not of the same size, and spaced evenly. This will, of course, apply to both the dovetails and the gains, or the tenons and mortises. The test of spacing the dovetails is to get your stuff to a width, then the same gauge does for both sides of the tenons without moving, and for cutting the gains. The method shown in Fig. 12 will give the best results, because the cuts for the pieces *e, e* are made parallel with the saw and both at one time; then as the angles formed by the two sides *b* and *c* of the sliding gauge are equal, it follows that the distance between the saw and either one of the pieces *e* will always equal the distance between the saw and the other piece.

This manner of cutting dovetails may be used for making snap-flasks, or for any other purpose where a good many pieces are to be made all alike. It would not pay for only a few.

In sawing mitres (horizontal), as for picture-frames, it is evident that unless the opposite sides are of the same length the joints won't fit; to get them of the same length, place one on top of the other and cut them both at once.

By using a gauge-piece similar to the one used in cutting staves, shown in Fig. 5, any number of pieces may be cut at once, as in making hexagonal or octagonal frames. This may also be done by putting a stop on slide after cutting one end of all the pieces to be sawed to the same length, and placing the cut end against the stop.

In sawing pieces off square and of the same length, where they are to be cut pretty short, as in cutting up stuff for gear-teeth, one very common way of gauging the length is by the fence; but if the stuff sawed is narrow, the pieces are liable to catch between the fence and the saw and make trouble, perhaps break something. A better way is to fasten a piece down on table, back from the saw, in such a position that when the stuff is drawn back for another cut, the end may be pushed against this piece, thus gauging the length; then when it is moved up to the saw it is left all clear. This may also be accomplished by a piece placed against the fence and kept back from the saw. If you still persist in using the fence alone for a gauge, just count your fingers after you have done sawing to be sure that you still have the right number.

CHAPTER X.

THE LATHE.

THE lathe is another very essential tool in pattern work. In fact, patternmakers could hardly keep house without one at least in the shop, and there should be two in order to do the great variety of work which comes to nearly all shops. We must have a lathe large enough to swing the big pieces, and as this big lathe cannot be run at a high speed without a great waste of power and excessive wear, it will be good economy to put in a small lathe for the small work.

The number and size of lathes necessary for any particular shop will be governed by the size and kind of work to be done. Some shops can get along with one lathe, or, perhaps, only the occasional use of a lathe, while some other shops—as, for instance, a shop where steam and water fittings are made for plumbers—need a lathe for every man, and a good lathe, though it needn't be very large.

There are plenty of lathes running every day now that ought to have been out on the scrap-heap ten or fifteen years ago. The pattern-shop is a kind of hospital or home for all the worn-out lathes in the works.

I have seen an old, worn-out engine-lathe, one that had probably never run over 1,200 to 1,500 revolutions, brought into the pattern-shop with the back gear and feed attachment removed, and expected to get right up to 4,000 turns a minute without any trouble. This expectation is, unfortunately for us poor patternmakers, not often realized.

I have tried to make patterns on a lathe where the face-plate slipped over the end of lathe spindle, and fastened with a set-screw, and as the end of spindle was at least $\frac{1}{32}''$ smaller than the hole through face-plate, any job you happened to be turning had to be finished without taking it out of the lathe, and I guess every man in the shop got his knuckles rapped by the set-screw. It seemed to me sometimes as though it was all set-screw, and every time you touched the work it would revolve on a new centre. Another lathe in the same shop had wooden shears, but it was a good-running lathe, as the head was fitted up nicely, and had a wooden cone. We usually had the luck to get lathes in the pattern-shop with iron cones, and with the large end of cone toward the front end of spindle. This is because they have been engine-lathes or brass-finishers' lathes, and the iron cone wrong end foremost was all right for the purpose the lathe was intended for. But this lathe had a wooden cone with the right end—that is, the small end—toward the front end of spindle. The only trouble with this lathe was speed. It ran too fast. On the fastest speed you could hear it hum, and it probably made 6,000 turns a minute. This was too much for a lathe that would turn 28″ in diameter over bed, and which was also made extra heavy for face-plate work, for which the back end of spindle was threaded.

I can also remember another lathe with wooden shears, about the same size but not so good a lathe, and at the time I used it it was badly worn. You could hear the spindle rattle all over the shop when it was running. The face-plates on this lathe were all right, but the hole in spindle for the spur-centre was not central. Therefore, if a job was removed from the lathe and the spur-centre taken out for any reason, it was almost impossible to get the work back in the lathe so that it would run true.

The tail-centre was never in line with the spindle, but this isn't absolutely essential for a turning-lathe where all the work is done with hand tools; still, the lathe would work better if the two were kept in line.

These are a few specimens of the lathes generally found in pattern shops, and are a fair sample of the general quality of these tools. There are some shops, and it is a pity there are not more, where you may find good tools, which were made for the purpose they are serving.

Here, again, is another trouble: There are a great many patternmakers, as there are men in all other trades, whose chief and seemingly only object in life is to pass away the time between two consecutive pay-days in the easiest possible manner. Such men as these always use a lathe without looking to see if it wants oiling. In fact, the only time they ever oil a machine is when the need of it is brought to their notice by the spindle getting hot, and perhaps stopping. There is probably no class of machinery so easily injured by neglect in this particular as high-speed woodworking machinery; consequently, one of these men can do a great deal of harm in a very short time. I call to mind a recent case of this kind, where a lathe was used without oiling, got hot and stopped; then the man using it, in order to make it run so that he could finish his job, oiled it, and, finding that didn't entirely cure it, he loosened the set-screw at tail end of spindle, and also loosened the cap-screws in both boxes. The lathe didn't get over it for three months, and I don't know as it has fully recovered yet.

There was a time when it was not considered necessary—perhaps it was also thought to be impossible, or at least impracticable—to turn wood by means of any tool but a hand tool. A wood-turning lathe, fitted with a slide-rest, would have been looked upon as a great curiosity not many years ago. Now lathes fitted up in this way are getting quite common.

There was also a time when iron was turned altogether by hand. Now the machinist has the slide-rest with automatic feed in any direction, and the patternmaker also has the slide rest, but usually without the automatic feed. The speed at which it is necessary to run in turning wood, in order to cut it smoothly, makes it difficult to use an automatic feed, as, for instance, in cutting a screw. I have seen this done on soft, dry pine in an engine-lathe, but it wasn't a job to be proud of, and had to be all dressed over by hand before it was anywhere near smooth enough to mould. Hard-wood works better. Rolls having a spiral groove turned on their surfaces are made successfully from any close-grained, hard wood. Such rolls are often used for winding the cable on elevators. I think, as a rule, that the automatic feed would be a hindrance rather than a help in wood-turning. It is, of course, used on lathes which are especially adapted to some one thing, as making broom-handles; but this is entirely different from the turning done in pattern work. The speed at which the feed would have to run, in order to work successfully and economically, is, perhaps, the very reason that it cannot be used with satisfactory results.

The requisites of a good speed lathe are a well-fitted spindle, having a taper-hole bored in front end for centres, and a thread cut on the front end for face-plates, leaving a good liberal shoulder for them to bear against. The lathe should have wooden cones on both spindle and countershaft, in order that the lathe may be stopped and started quickly. The smallest step of cone on spindle should be toward the front end. This will give more room when working close to the lathe head, as in turning the back side of a piece on a face-plate.

The tail-centre should be in line with the spindle and have a taper-hole the same as in spindle, then all centres and chucks that are fitted in the live spindle may also be used in the tail spindle. If the live spindle has brass boxes, see that they are well supported by the housings. The boxes should not be much longer than the thickness of housing, otherwise they are liable to spring and wear unevenly, which will soon make them run hot.

The tail spindle should be moved by a screw, and provided with a clamp for fastening firmly at any point.

The saddle and rest should be made so as to be adjusted and fastened in any position, without the use of a wrench, or any tool except what constitutes a part of the saddle or rest. A great many rests are fastened in position as regards height by a square-headed set-screw, and every time any change is made in the position it is necessary to first find the wrench which fits this screw, and if a monkey-wrench is used it will of course have to be adjusted to fit the screw before using. How much better a set-screw fitted with a lever handle works, both as regards the rest and also the operator's temper.

The speed at which a lathe should run depends upon its size and the work to be done. A very good speed for a lathe that will turn 12″ in diameter would be on the fastest speed 4,500 revolutions, and on the slowest speed from 500 to 800 revolutions. This cannot be considered as an arbitrary rule for all classes of work, as there is a great difference in the work done by the same size lathe in different shops, and it isn't every 12″ lathe that can be coaxed or even compelled to run 4,500 turns a minute.

Faster speed than this means an extra fine lathe or a loose spindle and excessive wear. If you are fortunate enough to possess a lathe that can be run at this speed and keep cool, don't let anybody tinker with it on any pretense, for in nineteen cases out of twenty they will do it harm. Even taking out the spindle to clean it is bad. It is better to clean it without removing it from the boxes, and a still better way is to use such oil as won't make any dirt, unless you let it get hot enough to burn the oil. To prevent this, put a piece of rawhide between set-screw and tail end of spindle, keep both boxes well oiled, and don't get the belt too tight.

Never locate the counter directly over the lathe spindle. Put it back so that the belt won't be exactly vertical. This helps the belt a little. Then use a belt as wide as possible, lace the belt with wire or shave down the ends and lap them and glue them. After the glue has set, sew the splice as belts are sewed which are made without rivets, using a small thin lacing and pounding it down flat after sewing. Make the belt just tight enough to do the work. Then if you find that the belt slips, it is likely that you are trying to make the lathe do a job that properly belongs to the big lathe, or perhaps you are working on the same principle as one of my former shop-mates, who, when he had a piece in the lathe that had a good deal to be turned off, would point his gouge at the most prominent point, shut his eyes, and jam in the gouge. If the lathe didn't stop, or nothing broke or gave way, he usually succeeded in jamming off considerable wood, but his method was rather hard on tools and the lathe.

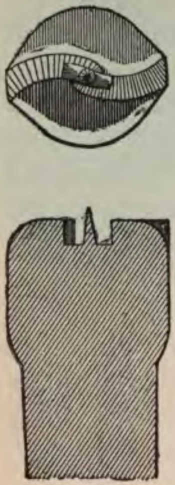
FIG. 13.

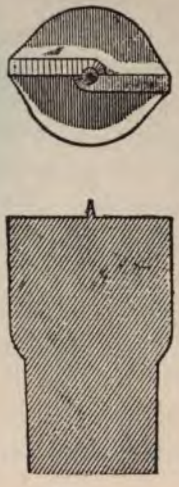
FIG. 14.

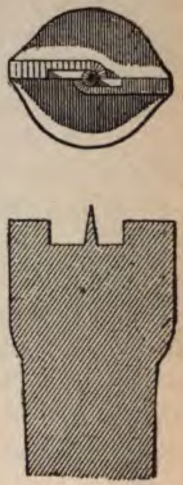
FIG. 15.

The centres for driving work may be of many different forms, some of which I have endeavored to show by drawings.

Fig. 13 looks and works very nicely while it is kept in good order, but it is rather difficult to repair if the wings get broken, and it is also one that is expensive to make in the first place. That shown by Fig. 14 costs less and works fully as well as Fig. 13. This one may have a notch filed in one wing to locate its position in the piece to be turned, and insure its being always put back in the same position

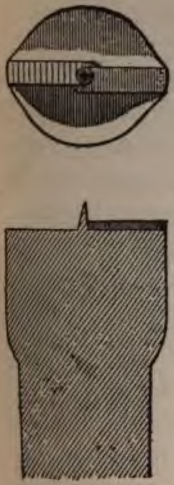
Fig. 16.

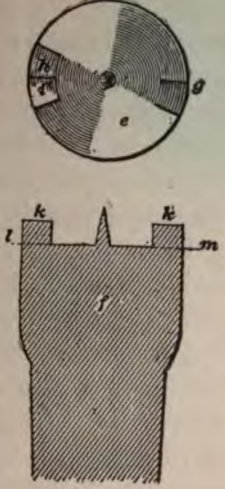

Fig. 17.

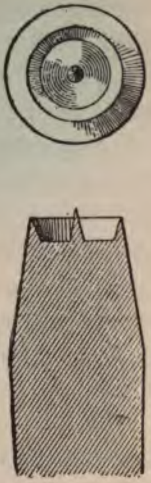
Fig. 18.

in a job that has been taken out of the lathe for any reason.

The one shown by Fig. 15 is the same as Fig. 14, except that a space is cut between the centre point and the wings, one of which is wider than the other, to locate its position in the piece to be turned.

Fig. 16 shows a form similar to Fig. 14, except that the line of wings form tangents to central point instead of radial lines. This form may be marked by filing a notch in one wing, as in Fig. 14, or by cutting a space, as in 13 and 15. It is best on all of these four centres to have the wings cut away where they join the centre point, as in Figs. 13 and 15, in order to sharpen the spurs without spoiling the centre point; also to give room to turn up the centre when necessary.

Fig. 17 shows two views of another form of spur centre, *e* being an end-view, where *g*, *h*, *i* show the location of spurs. This is the best form I know of for small work, and its having two spurs on one side and only one on the other makes it possible to replace any piece of work that has been taken out of the lathe, and to be sure that it will run true. More points may be left if it is thought best, as in making this centre it is turned up with a longitudinal section like *f*, then the ring at *k* is cut away, leaving the spurs at *g*, *h*, *i*, and as many more as you wish. This centre is intended to be forced into the work up to the line *lm*, then it has no corners to catch the clothing or rap the fingers. This is another good feature.

The central point on all these different centres should be kept a little longer than the spurs or wings. In order to locate the centre in the work accurately, keep this point always turned true at an angle not over 23°, to avoid crowding open the joint on split patterns.

The tail centre may be an ordinary 60° centre, but this form is likely to crowd open the joint, and for a job that has a long spell in the lathe, it is liable to wear toward one side of a split pattern, as one side is almost invariably softer than the other. A centre having a slender point, with a ring around it from ⅜″ to ¾″ in diameter, will prevent both these troubles. It should have a section like the one shown in Fig. 18.

I have shown both this dead centre, Fig. 18, and the spur centre, Fig. 17, as being made from a single piece of steel, but an improvement is to put the centre point in as a separate piece; and if Stubbs' steel is used for this point, it may be easily replaced if it gets broken.

I have turned small split patterns of hard-wood without any fastening but the dowels and such as are afforded by centres like Figs. 17 and 18. This wouldn't be a good way as a rule, but it shows that the centres are both excellent in their way. A centre might be designed for live spindle that would safely hold small, light work, and would be a desirable tool.

In preparing work for the lathe it is necessary to provide some way of holding split patterns firmly together. Small patterns may be held together by gluing a short space at each end, beyond the length of finished piece, but if fastened in this way the turning must all be done before separating the pattern. A better way is to put a screw in each end, then you may take the work apart as many times as you wish. This is sometimes desirable, as, for instance, in turning a piece any portion of which is required to be as nearly a perfect sphere as possible. After the pattern has been centred accurately in the joint, turn down a place opposite the centre of ball to the size required, and make a line to locate centre of ball, then take the pattern apart and draw the centre line across one half, strike a circle the diameter of required ball, having its centre located on line already made, and with your knife or a chisel cut off one side of pattern to the line of circle, taking care to cut off the right side. This will be on the side of joint toward you, at the top, as the pattern revolves in the lathe, or hold the half pattern with the live centre end toward you and the joint up, and cut off the right-hand side. Replace the pattern in the lathe and turn down just to this line and you will have, practically, a true sphere. Any split pattern, the outline of whose surface is composed of curved lines which are hard to locate from the outside, may be laid out in this way and turned up more accurately than is possible in any other way. The lathe should be stopped as often as is necessary to note where you must cut away the pattern. If your lathe has iron cones on counter and spindle you won't get along as fast as you could if they were properly provided with wooden cones, as it takes longer to stop and start the heavy iron ones.

Large split patterns may be held together by dogs driven in each end, at one or both sides of the centres, or hardwood centres may be used, like Fig. 19. Iron plates are sometimes used similar to Fig. 19, but these are hard on the lathe centres, especially the tail centre when it isn't in line with the spindle, although they may be used at the spindle end in connection with some form of lathe-dog for driving the work. In all cases a wooden centre piece at tail end, with a centre like Fig. 18, will always wear well and run true. I have seen an ordinary face-plate put on head end of pattern and then screwed on the spindle. At the same time an iron plate was put on the opposite end of pattern

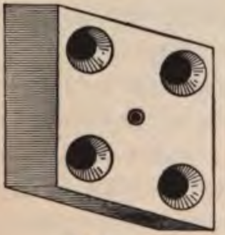

FIG. 19.

for tail centre. This is a poor way. How are you going to square off the end of pattern for face-plate so that it will run exactly true? that is, supposing the tail centre to be in line with spindle. If it isn't in line, it won't make any difference whether the end is square with spindle or not—it is bound to strain the lathe.

After the face-plate is fastened on the work and then screwed on the spindle, it forms a rigid joint between spindle and work, and they will revolve as one piece, or, more correctly, will strive so to do. The axis of revolution* will be a straight line, drawn from the centre of spindle to the tail centre; and if the tail centre isn't in line, this axial line won't pass through the centre of front journal box, so your lathe will probably run hot. This is illustrated by Fig. 20, where the tail centre is below line of spindle. Heavy split patterns should not be run at too high a speed, as the centrifugal force generated will spring open the joint, and as a result the pattern, when finished, will not be round.

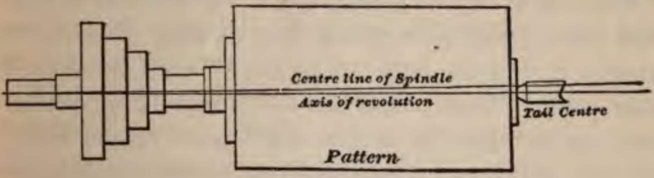

FIG. 20.

Care should be taken in centring split patterns for the lathe. Get the centre exactly in the joint, especially if the pattern is to be made of more than one piece; and if it is only one piece, and has any part of it squared up, how can you square it accurately if the pattern isn't parted at the centre? If the pattern is made up of two or more pieces, and you get these pieces all centred out of the joint, how can you tell when the centres are all located in the correct plane? And if the casting is to be hollow, how will you make the core-box so as to leave the casting of the right thickness throughout?

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* By this I mean the axis about which the pattern and spindle, now held rigidly together by face-plate, would strive to revolve.

There is a way of getting round all these difficulties. You may fit your pattern together, making offsets in the parting, to keep the centres of all the different pieces in the same plane. These offsets give the pattern a kind of rustic look, and perhaps the moulder will have to borrow a step-ladder to get up and down over these offsetts, in making his parting. They will also help to make a poor casting.

Another, and a much better way, is to locate the centre exactly in the joint of each and every piece.

Face-plates should be put on with a well-fitted thread and a good liberal shoulder. You will find it very easy to get one fast on the spindle, if the thread is a loose fit and the shoulder small. On the contrary, when they are properly fitted, it will be a pretty hard matter to get one fast; but as we are all liable to meet with accidents when turning, we may be so unfortunate as to get one stuck fast.

To prevent this I have found a paper washer, well-soaked in oil and placed between face-plate and shoulder on spindle, to be a good thing. If you have never tried this, you will be surprised to see what a difference it will make. To keep the dirt from collecting on the thread inside face-plate hub, file a notch across the thread on spindle; just where it becomes a full thread, cut the notch to the full depth of thread. Then, if you keep the notch clean, it will, in turn, clean out thread inside face-plate. This won't work very well if the thread is a loose fit.

Some lathes intended for very heavy face-plate work have no thread cut on spindle, but instead the end of spindle is turned to a slight taper, and the face-plate bored to fit, and is drawn up to the shoulder on spindle by a taper key passing through the hub of face-plate and through spindle. A face-plate fitted in this way don't get stuck on the spindle.

A small face-plate fitted to go into the taper hole in either live spindle or tail spindle is sometimes very useful.

A great many tools may be made for the lathe which are useful either in saving time or by bettering the quality of work turned out, but as these are to a great extent what may be called special tools, I shall not mention many of them. There are some that are useful to all; among these are a chuck for drills and another for bits with square ends; both these chucks should be fitted to either spindle. Then a pair of female centres are very handy on small work. Make the live one on a very slight taper, that it may centre and hold any round piece that will go into the centre.

In fitting centres, chucks, and all other tools for a speed-lathe, you should always keep them as close to the housing as possible. In other words, make them as short as you can, and as light as is consistent with strength. Weight in any part of a speed-lathe which revolves with the spindle is something to be avoided, especially where it is in such shape as to overhang the bearing; for while it doesn't matter much about the weight if it is perfectly balanced, it is hard on the front bearing of spindle, where it overhangs much. Then, if it is a tool to drive some piece of work, the nearer the work is to the journal the better it is for both work and lathe. Again, if it, the tool, isn't balanced and is also made to project away out toward the other end of lathe, you will have hard work to keep the lathe from running hot or to turn up a piece of work round and true.

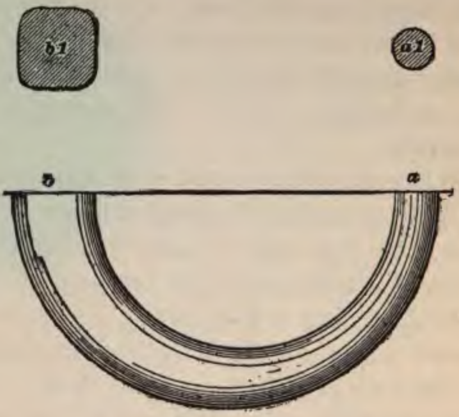

FIG. 21.

Fig. 21 shows a peculiar job of turning. The finished piece was to be like the figure, *b*1 being a section at *b*, and *a*1 a section at *a*. To get this piece I turned a whole circle, and after I had spent a couple of hours in chucking and rechucking it, and taking great care to have the taper both ways very regular, the man who ordered it, and who had been standing at my elbow all this time, watching the development, kindly informed me that he wanted it to form a gate for running a small gear from the bottom of hub.

A piece that would have answered for this I could have made in about fifteen minutes, so you may imagine how pleased I was to hear what it was for. I felt like throwing the piece at his head, but didn't, and I suppose that he had the most expensive gate of the kind that a moulder ever used.

CHAPTER XI.

FILLETS.

THE mere thought of fillets is enough to make most patternmakers feel tired. Fillets worked out of the solid wood of the pattern oftentime resemble almost anything but what they are intended for, being more or less cut and hacked, and varying in size and shape according to their location. They are generally pretty good when they follow the outside of a curve, but when they are on the inside of a curve of short radius, and the grain of the wood runs the wrong way, it does seem as though the patternmaker's trade was a little the worst business in the world.

Sometimes wood fillets are made and put into the corners, but they are not adapted to crooked corners, and it is hard to make the thin edges lay down tight. Even after they are put in in good shape, after being moulded a few times the edges begin to curl up, and if any glue has been used it works out and makes the moulder unhappy. A good way, when glue is used, is to wet the outside. Then the edges will stay down until the glue sets.

There have been various ways devised to overcome these difficulties. A favorite method is to make the fillet of leather. To accomplish this, a plane has been devised which, when it is in good order and in skilful hands, will shave off a strip of leather with a section like *a*, Fig. 22. This, after being wet and well rubbed into the corners with varnish, to make it stick, will look very well if you don't expect too much. There will be a hollow wherever a nail is driven, and a corresponding fulness at the edge. If the angle is very crooked, the leather fillet will look like the crimped edge of an old-fashioned pumpkin pie; but any little irregularities like these can be overlooked, for the leather fillet is really a very good fillet, having one quality, durability, which other fillets have not.

Then there are wax fillets, and fillets of putty, which look better or worse according to the skill and tools used. I have found a round rod of the same radius as the fillet, and having the end turned off round, to work first-rate. For wax, warm the rod so that it will not stick; for putty, wet it.

The best fillet made is when it is worked out solid. For crooked places, the fillet is worked on a piece by itself, like *b* in the cut. But, owing to the time necessary to do this in good shape, and the consequent cost, it is often dispensed with, and some cheaper method used. Putty and wax are both cheaper. Wax is probably the most used, as it is easier to work and gives better results for the time expended. For large fillets, putty is perhaps better after it gets hard, which takes a long time. The angles should have a light coat of lead and oil, before using the putty, or it will not stick.

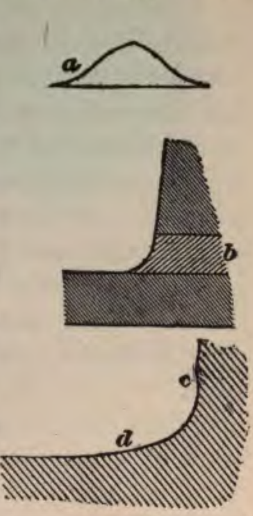

FIG. 22

When you turn a fillet between a flange and body, don't cut in too deep, like *c*. This makes the moulder trouble. Also, do not go to the other extreme and begin the fillet half way across the pattern, like *d*.

It is sometimes necessary to make a pattern in a hurry, and then perhaps you will be persuaded to let the moulder cut the fillets out of the sand. I don't know whether this gives the moulder any satisfaction, but, as a rule, the appearance of the casting isn't such as to give much pleasure. It is hard for the moulder to make a sharp corner of sand from the nature of the material; neither is it always practicable or advisable to put fillets in all corners, so we shall probably go on about the same as usual, some using wood or leather and putting in the hard places with wax or putty, and giving the moulder, and the man who pays, more or less satisfaction—more for the moulder when the corners don't break away, and less for the payee when the bill is large.

CHAPTER XII.

STAVEWORK.

PATTERNS for round pieces are made solid when not too large or if they are very irregular in outline. When the outline is nearly straight, with the exception of flanges, which may be put on, the patterns may be made to advantage by gluing up the stuff in staves. Possibly every patternmaker has had some experience with stavework either on pipes or cylinder patterns, and each one may have some ideas of his own on the subject, or he will if he takes the interest in his work that he should to insure success. I don't mean to say that my way of putting up stavework is the best; still, it will compare very favorably, as regards time, with any way I have ever seen. And there may be nothing original in this one method, yet it will be new to some, and to these I will try to make it plain.

If your pattern isn't too large in diameter, say 14″ or 16″, you can make the heads out of plank. For larger work a better job can be made by gluing up the heads similar to cant or segment work, making them in half-circles, closing the straight sides, or what will be the joint of pattern, by courses of the same thickness as cants and lapped back and forth at the joint where they join the circle. You can also put in arms where the work is very large. These large heads should be jointed together in pairs and then laid out. They may be turned if you wish, and then, by working out

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which is parallel with saw, in connection with this gauge. In Fig. 23 the two sides *c* and *e* are to be cut by the help of gauge, shown in Fig. 24.

For any number of sides up to eighteen I should saw all but the last three by the bevel gauge and the next two by the fence and wedge. The last side *d* needs no gauge, as it is parallel with side *s*, *i*. Don't throw away the gauge, Fig. 24, but mark the number of sides on head, bore a hole through it, and hang it up ready for the next job having the same number of staves. The diameter of pipe or cylinder makes no difference with the angles.

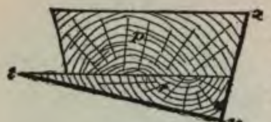


FIG. 25.

You will find when you have finished the heads that they are more accurate than would have been the case had you tried to lay them out before working. Also, if there is any irregularity in one, it will be repeated in each head, so that all the faces will come parallel. This, as you see, overcomes one difficulty in stavework. You must keep your saw in good shape, for you can't do this job with a poor saw and make it satisfactory.

If you are going to close over the joint of your pattern, you must saw from the joint of heads the thickness of stuff, as shown by broken line *o*, Fig. 26, that you will put into the joint. I don't think this is any improvement; in fact, I should rather leave the pattern open, and give it a good coat of paint inside to keep out the water. If it is closed up it will gather moisture inside, and then when the pattern is laid away the outside will dry first. This will try *the joints* and probably start some of them. If you make up your mind to close over the joint, get out your stuff and fasten the heads to it in their right places, taking care to get them square with the axis of pattern and all on one straight line, else your staves won't fit. For an open pattern, fasten the heads on a flat board in their places, keeping them square and all on a line, and setting the end heads out far enough to clean up in good shape when you turn up the piece.

I cut up the staves in this way: Make a piece a couple of feet long, having a section like *r* in Fig. 25. Let *p* be a section of a stave; then make the piece *r* of such section as will make the angle *t*, *y*, *x*, formed by the combined sections of stave and piece *r*, a right angle. The width of this piece I should make not far from the width of stave. Put this piece on saw-table between slitting saw and fence, with the thick edge toward saw. Now, having your stuff for staves cut up to the right length, the small cut shows a section of one of these pieces before splitting into staves. The lines 1, 2, 3, 4 show where it is to be sawed. Begin by sawing one stave from each piece a little wider than necessary.

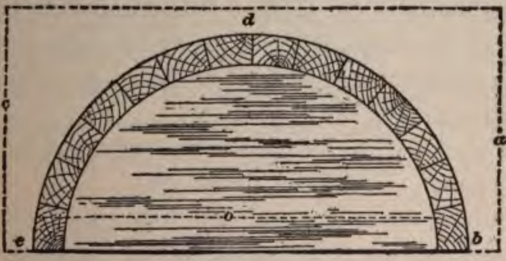


FIG. 26.

Then you must reset the fence. If the fence is made to tilt, set it to fit the bevel or stave. If you can't do this, get a piece to lay between fence and bevel edge of stave; for, if you gauge the width of stave from long corner, they will vary in width with the thickness of stuff used. By setting the piece *r* with the thick edge toward the saw, and then tilting the fence to fit the bevel of stave, you gauge the width of the staves on the inside surface regardless of the thickness of stuff. And then by turning over your stuff every time you cut off a stave you can save time and material. You will also be able to cut the staves closer to the finished size because you work from the inside of stave. This is the side to get to size, as the width of staves on the outside is regulated by their thickness. You may, in fact, with a keen saw and a good solid saw-table, cut them to the exact width and angle. Perhaps, to be on the safe side, you had best cut them a little wide, then joint one edge of all the staves straight and to the right angle, and then you could cut the other edge on the saw, making them at the same time of the right width.

Mark piece *r* with the number of staves and hang it up with the gauge, Fig. 24, for future use.

If you have made the heads like Fig. 23, put on stave *d* first, using screws and counter-boring for the heads so that the holes may be plugged. For heads like Fig. 26 you can begin at the joint, and if the joint is to be closed over begin on each side, putting in the top staves *d* last.

This will finish up one-half of the pattern. For the last half, if it is an open pattern, turn over the half already built up, and place the remaining heads, each on its mate, which has already been fastened into the first half, then begin putting on the staves as before. For a closed pattern each half may be built by itself, as it isn't necessary to have the heads match as closely as in an open pattern.

Core boxes may also be made up of staves for a great many jobs. For these the heads will of course be on the outside. The usual way is to cut the heads out on a circle, allowing for the thickness of staves, then set them in position, and fit in the staves, beginning in the bottom. Another way is to glue up the staves without any heads, then work out the inside of your box, cut it off to the right length, making draft on the ends, then nail on a piece of stuff at each end, which will form the head and also the end of box as shown by broken line *b*, *a*, *c*, *e*, Fig. 26. Now turn your box bottom side up and glue a block on inside of head under each stave.

Another and better way to put on the heads, after you have worked out your box, is to gauge the staves at the ends of box to a thickness from the inside. Then cut them to this thickness back an inch or two from the ends. Put the two pieces for ends of box in the lathe and turn a groove that the ends of staves will fit into, and also turn off the draft necessary to get out the core, then fasten them on the ends of box. Where the staves are put on in either of the last two ways it makes a stronger box than when the heads are cut out to fit around the outside of staves, for then you have a weak place at *b* and *e*. If you want any heads between the two ends they will have to be fitted around the outside of staves.

CHAPTER XIII.

CANT OR SEGMENT WORK.

When we wish to make circular forms that are comparatively thin and fragile, like a pulley rim, or that are expected to keep round and true, like a pipe-flange, we can improve both the quality and strength of the job by making the piece up in layers, or "courses," as they are technically called, each course consisting of six or more pieces, to be cut with the grain running in the longest direction of the piece; as it would, evidently, be of no advantage to saw out, in one complete circle, the material for a course and then cut it into segments or "cants."

In Fig. 27 I show a ring which is made up of "cants," having six cants in each of the four courses. Beginning with course *A*, we cut six segments; and by the way, one-sixth of a circle is spanned by a chord equal to its radius, which makes it very easy to lay off the length of the cant, and as long as we stick to this division into six parts we don't need to make any templets for laying out the work, as the first cant laid out for each course forms a templet for the remaining five, it being very easy to lay down the length of this cant without drawing the full circle. In fact, when we have set the dividers or trams for the radius we have also set them for the length or chord of the 60° segment.

To return to course *A*, Fig. 27: This first course is set up on the face-plate, as it is presumed that you will use the lathe to face off each course in the process of building up the ring. If the finished ring is to be very light, this first course may be glued fast to the face-plate, taking the chance that the completed ring may spring out of round when cut off from the plate. It will usually be found that there will be enough glue forced out of the joints between the ends of cants in the first course to secure them firmly to the plate. If the ring is to be long and heavy, this first

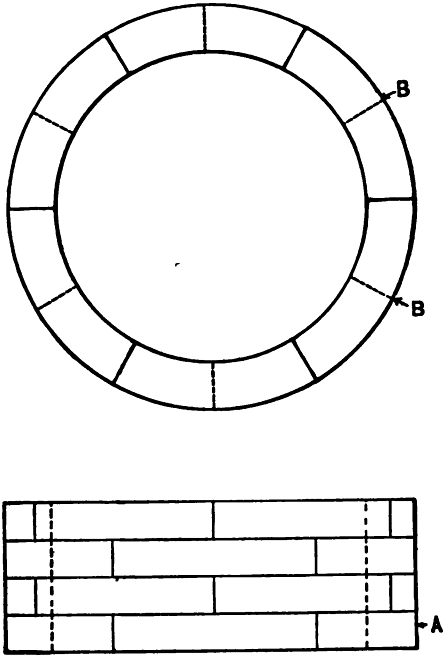


FIG. 27.

course had better be fastened to face-plate by one or two screws in each cant, put in from back side of plate after the glue in joints of this course has dried.

In putting on each succeeding course, locate the joints between the ends of cants, midway between those of the preceding course, as shown by broken lines *B*, *B*, in Fig. 27.

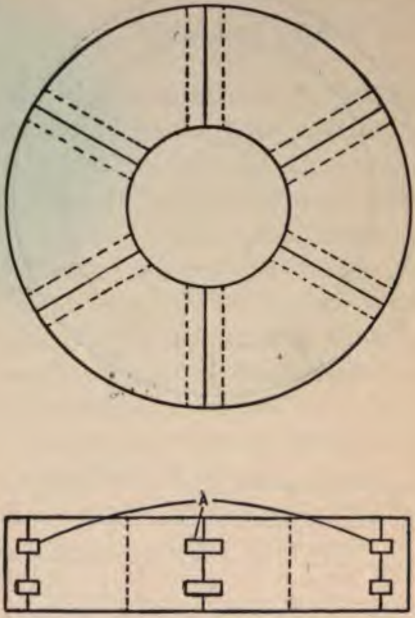


FIG. 28.

Another method of putting up cants is shown in Fig. 28, in which it is seen that but one "course" is made and that the cants are tied together by the "feathers" *A*, *A*, *A*. This method requires that the cants be fitted together, then grooved for the feathers, which should be made with the grain of the wood running directly across the joint. It requires some care on the workman's part to bring all of the joints together and at the same time have them properly glued, still this method is frequently used for short, circular patterns.

In building up light work of this kind, care must be used to avoid springing each cant when forcing it into place, or it will be found, after the ring is turned off, that each cant, so sprung, is striving to regain its normal shape, and the result will be anything but pleasing.

An ingenious way of avoiding this result is to cut the cants from very thick stock and to use care in making the joints between ends of first course; if possible, make this first course thick enough for the complete ring. After this first course has been glued to the face-plate and the glue has dried, take it to the lathe and face off level, then turn circumference of ring *and* face-plate square with face, take the work to the circular saw and cut from its face side, holding the true face against the splitting fence, and the circumference on surface of saw-bench, all but the thickness decided upon for the first course. Then return to the lathe, face off the new surface left by saw, then, reversing the ring cut off by saw, place its faced surface upon the first course, not forgetting to turn it round so as to "break joints" with the first course, and glue it fast in place.

Going through the same series of operations a second time leaves two courses on face-plate and a somewhat thinner ring ready to be glued down for the third course. The advantage of this method lies in the fact that you have at all times a complete ring to be glued down to face-plate, and as this ring will, or should be, much more rigid than any single cant, the danger of introducing strains when building up is greatly reduced.

A good general rule for the thickness of courses is to make them somewhat less than the finished thickness of ring, measured radially.

It is not essential to the success of this class of pattern work that the joints between ends of cants in each course be made "good"; in fact, for most jobs the band-saw will make good enough joints for all except first and last courses, in a straight ring like Fig. 27.

Where portions of radial joints are exposed on the finished surface, they had best be made "close," to preserve a good surface.

Any piece of work made up in this way should be allowed to dry thoroughly before working, else the drying of the glue is liable to draw the pattern out of shape. If the piece is to be cut into two or more pieces, do this before finishing or turning and thus give the parts a chance to adjust themselves to the strains that may have been introduced in gluing up.

PART THIRD.

SOME EXAMPLES OF WOOD PATTERNS.

CHAPTER I.

PATTERNS FOR BELT PULLEYS.

It is evident that a set of patterns for manufacturing belt pulleys to any extent must, to be practical, be capable of almost endless combinations in order to embrace all the different diameters, widths of face, sizes of shaft, and length of hubs. The different combinations of sizes would at first sight seem to require a great many patterns, each one complete in itself; and at the time when it was customary to make crooked arms it was almost impossible to make a set of patterns that would fit nearly every orde so that special patterns would be the exception and n the rule.

The present custom of making straight arms has m it possible to construct a set of good durable patterns very reasonable expense, and one from which, by m of the great number of combinations made possible will be able to make a pulley of almost any descri provided you carry the system far enough.

The rings for the rims may be made by sweeps, the small sizes, which will require patterns. The should be cast thick enough to turn up, inside side, before using for patterns.

It will be necessary to make two, or perhaps ferent weights of spiders for each ring. If it is keep the number of arms uniform all through difference in weight of the spiders is made by varying the size of the arms; or, if strength only is to be considered, a pulley may be made heavier by increasing the number of arms. I should consider this last way the best, as the iron will be distributed better and will consequently make a stronger pulley. There are exceptions to this rule, as in the case of a pulley having a rib on the inside of rim between arms. Such a pulley may be cast with heavier arms than one having no rib inside of rim, but this last style may be made as strong as the other by increasing the number of arms.

A description of the manner of constructing a single spider or a series of spiders will answer for all.

I have shown in Figs. 29, 30, 31, and 32 the way of making a series of six-arm spiders for different diameters of pulleys. Make a pattern for the centre Fig. 31—this is to be of the same thickness as arms, one of which is shown in Fig. 29. One arm is all you will find necessary to make in wood. I would make this arm a split pattern for the convenience of the moulder; or, if you are going to make all of your finished spiders in halves, a half-pattern is all that you will require. The end next to rim I would cut out of hard-wood, in order to keep the fillet in as good shape as possible.

As you have only one arm to work out, you can afford to take extra pains in shaping and finishing it. The hard-wood end should be made with the grain running in the direction of rim, and don't try to make the fillet too thin on the edge; bring it down to an edge, but make the angle of edge great enough to mould and run sharp and clean. The letter *a*, Fig. 29, shows where the hard-wood end is joined to arm. This end should be put on with screws only, for reasons given further on.

Make the arm the extreme length thought advisable for this size of arm, not forgetting that more than six arms may be used.

Have one casting made off of centre piece, Fig. 31, and six from arm, Fig. 29.

Clean up the casting for centre piece, then lay out the shoulders *b*, *c*, *d*, Fig. 31, and file them up accurately—that is, make them all at the same distance from centre, and drill the holes *e*, *f*, *g*, which shall have their centres equidistant and also on the line of joint between arm and centre. These half-holes may be filed if thought best. The arms should be cleaned up, and a pin-hole drilled through the centre, and at a short distance from the outer end of each one, as at *h*, Fig. 29.

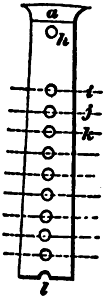


FIG. 29.

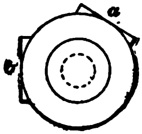


FIG. 30.

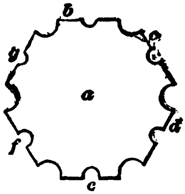


FIG. 31.

Now make a follow-board large enough to lay this spider on to mould. Put on the centre piece, Fig. 31, and drive a pin at each of the holes *e*, *f*, *g*, etc.; then from the centre *a* scribe a circle equal to the size of the largest spider to be made from these arms; space it off into six parts marking the six points opposite the pins *e*, *f*, *g*, Fig. 32. Draw lines from these points to centre *a*; these lines will be the centre line of each arm. Now mark the position of shoulder *b*, *c*, *d*, etc., of centre piece, take off the casting, and remove the pins. Lay on one of the arms, making its centre coincide with the line on follow-board, and the outer end with the circle drawn. Hold it in this position and drill through the hole *h* into the board, and drive a pin. This pin should be fast in the arm, and the pins at *e*, *f*, *g* fast in the board.

Get the length of this arm to the shoulder of centre piece; fit all the arms on the board in the same way. Mark a centre line on each one, and space off, from the inner end, such distances as will equal one-half of the difference between the diameters of pulleys which you wish to make; from this size and number of arms, drill a hole through each of these points. Then space off the centre line of each arm on the follow-board, beginning at the centre of pin-hole *h* and going toward the centre, making the first space from *h* toward the centre equal to the first space on arm from shoulder *l* toward the outer end, and so making the spaces on the board and the arms similar, going toward the centre on board and toward the circumference on arms. Drill pin-holes in board at each space. Replace the pins *e f g*, lay on the centre and the six arms as in Fig. 32, and it is ready for the moulder. Each of the arms will have holes drilled as at *h*, *i*, *j*.

After making one or two castings from this, one for a solid pattern, two for a split-pattern, the six arms are to be cut off to the centre of first hole from the end *l*, Fig. 29, then they may be moved up toward the centre, the pins at *h* falling into the second circle of holes in the follow-board, and then we are ready to mould another size of spider.

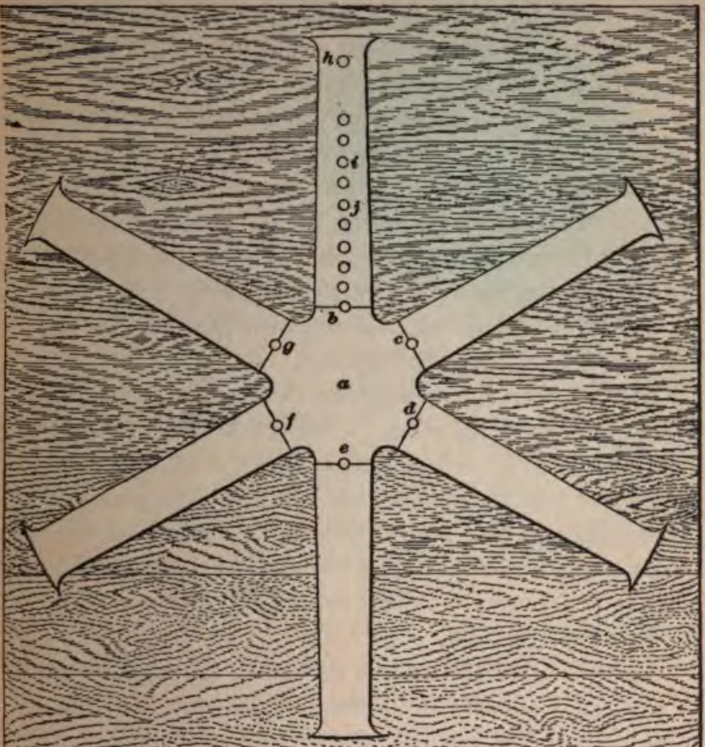


Fig. 32.

Thus we may go on cutting off the arms as shown by lines *i*, *j*, *k*, Fig. 29, and making a great many spiders from this one set of arms.

Now, let us illustrate the working. Sup wish to make a set of six-arm patterns, each diameter to have three sizes or grades of arms, light, medium, and heavy. We have made our wood pattern for a 72″ light spider from the same pattern by reducing the length, as has been explained. We will make, perhaps, light, 66″, 60″, 56″, 52″, and 48″; then, by still further reducing only the length, we will make medium 46″, 44″, 42″, 40″, 38″, and 36″; then below this diameter the spiders cast from this set of arms might be called heavy until they reach a point where the size of the arm is out of all proportion to the diameter. This is not intended for an arbitrary rule in making a series of spiders, but is given to show the practical working of the system. You can, of course, exercise you own judgment as to the right point to change the grade.

Another plan for making the three grades would be to vary the number of arms. This can be done by making three centres having different numbers of branches on each, but making them all of the same diameter, so that the spiders made from all three with the same length of arms would fit the same ring. In either case, it will require but very few wood patterns to make a most complete set of iron spiders.

These iron spider patterns should be accurately centred and drilled all with the same size drill for the hubs. I would make this hole not over ¾″; then, in case a pulley is ordered with a hub on only one side of spiders, the same hole will do for the pin on core print, which wouldn't always be the case if the hole was much larger.

If it is desired to make pulleys with ribs on the inside of rim between arms, cast the spiders with the ends of arms *at a, Fig.* 35, left off; then you can use the spider with these pieces which are to be cast separately, or with a rib made in as many segments as there are arms, and fastened to the arms with screws, or in any other way thought best.

The hubs can just as well be made of wood; then it will be easy to make any new or special hub. They should all have a $\frac{3}{4}''$ pin at the centre to fit the holes in spiders. Make the hole in outer end $\frac{3}{4}''$ also, in order that the print may take the place of the hub, as before explained.

It is a good plan to have the hubs fitted with bosses for set-screws, as shown at *a*, *b*, Fig. 30.

The core prints will, of course, all have $\frac{3}{4}''$ pins to fit the hubs.

The core-boxes for hubs may be made straight, but it is better to have a recess formed in the hub; this may be accomplished by a box like the one shown in Fig. 33. This is a top-view of box, which has one end movable to adjust it to the length of hub. It is then held in place by the screw *a*. The end *b* is left open to fill the box.

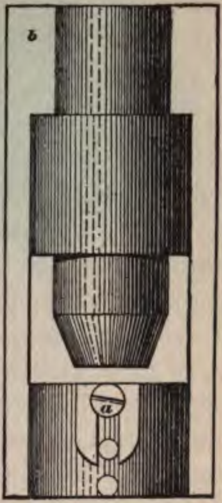


FIG. 33.

CHAPTER II.

PATTERNS FOR CABLE PULLEYS.

THESE pulleys, or sheaves, are sometimes made in a three-part flask when there is but a single groove, as in wheels for conveying power, where the wire or hemp cable takes the place of a flat belt.

There are some objections to this way of moulding sheaves, and the principal one is the necessarily fragile form it entails upon the pattern. Then the groove in some cases is very deep, which leaves a good deal of overhanging sand in the mould. As a rule, I think it is better to form the groove by cores. This will make a more substantial pattern. There will also be less work for the moulder, and less risk of losing the casting by reason of the sand breaking away which is to form the groove.

It will be seen by Fig. 34 that a pattern made to form the groove in green sand, by means of a three-part flask, would be a very weak affair. It could be made of iron, to be sure, but it is really of no advantage to make the pattern in this shape. I should make it with a core as follows:

Glue up the rim in cants or segments, putting in not less than three courses, and make the middle course (there should always be an odd number of courses in a pattern which is to have a set of arms in; or, rather, there should be a course in the right place and full thick enough to receive the arms, as it makes bad work where a part of two or three courses come within the thickness of the arms) full as thick as the arms if they are to be central, and after gluing on this course cut the arms in far enough across the rim to give them a good hold. The arms have already been glued together at the centre and planed off flat and true. Get the arms out wide enough to make the fillet where they join the rim, as is shown by Fig. 35, where *a* is the rim, *b* the arm.

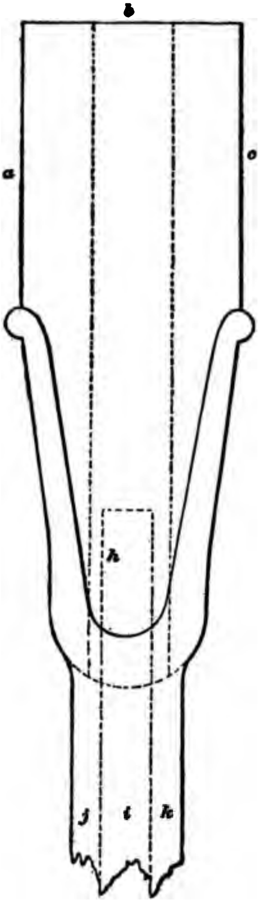


FIG. 34.

Before gluing the arms into rim, it saves time and trouble to lay them out and work them to the finished shape, except where they join the rim. If they are to have ribs on each side, before fastening on the hubs place the hub on a flat surface and then fit the ribs up to them, holding the ribs on a radial line from centre of hub. If the arms are tapered in thickness toward the rim, you had best put the hub in its place and fit the ribs against it on the spider. That portion of the rim which is included in the thickness of the arms must be turned up before putting them in.

After the arms are fastened in place put on the hubs and scribe around them so as to get the length of ribs. If the ribs were fitted against the hub while on the spider, the position of each one as regards length could be located by a knife mark. After the ribs are fitted against the rim, fasten on the hubs, then the ribs. I would cut off the hub on one side even with the rim, making the remaining portion of it loose. This will give the moulder a chance to lay the pattern on a plain follow-board. The ribs on the same side of arms may also be made loose, though I should rather make them of such shape that they might be readily coped off in the mould.

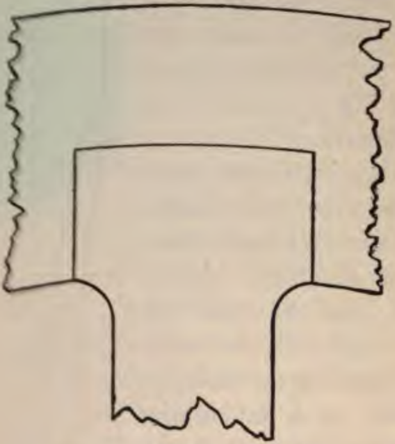


FIG. 35.

The shape of core-box in section may be seen by Fig. 34, and the length of it will be made to suit your own and the moulder's ideas, that is, if you consider the moulder's ideas on the subject of any account. If you don't, then look out for trouble when the pattern goes to the foundry.

You have very likely heard how easy it is to lead a horse to the brook, but it isn't so easy to make him drink if he don't wish to. The same difficulty is encountered in trying to make a moulder (or anybody else) do any work that he isn't, and doesn't wish to be, interested in the success of. There may be men who will honestly do their very best under such circumstances, but they are as scarce as hen's teeth.

The first move toward success in any undertaking is to get all who are to assist in its completion interested in its success, and how can this be done more easily, with the man who takes pride in knowing the whys and wherefores of his business (and, mark you, these are the men who are bound to succeed), than by asking for his ideas on that portion of the work which is his specialty, and, if there be no objection, letting him do it in his own way? In this way you ensure success, because, you see, you not only get the advantage of each one's skill, but you also, by leaving the manner of doing the work to his judgment, put him on his mettle, and he will do the very best he can. Many a casting which goes out into the back yard to be broken up may trace its downfall back to the designer who knows what he wants himself, or to the patternmaker who considers the moulder not as a mechanic but as a man who only knows how to shovel dirt. The designer or draughtsman may not understand all the branches through which his work must pass before it is completed, and if he is one who considers mechanics' ideas of no account he is very likely to get left, as the boys say.

I think it best and cheapest to make the groove in this sheave by means of a core, but still, if the moulder wanted to make it in green sand and I couldn't convince him of the error of his way, I would make the pattern to suit him, because, you see, I should want the casting to be as perfect as possible. If the pattern is made to suit the moulder and then you get a poor casting, you have him in a tight place.

If the moulder makes a success of the job in green sand, when you get a sheave to make like Fig. 36 you will be able to show him that he can also make a good sheave with cores, for I think any moulder will admit that it is best to make this four-grooved sheave with cores. After he has moulded it and finds out how well it works, I presume he will acknowledge that a single groove may be made equally as well with cores.

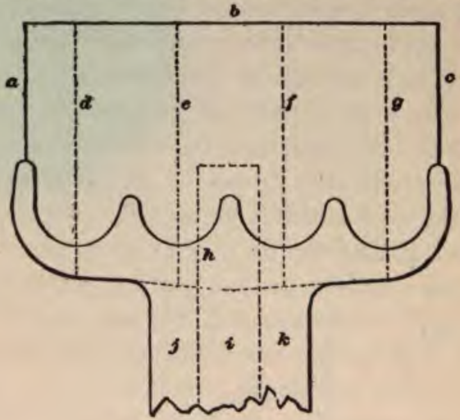


FIG. 36

The core prints for the two sheaves are shown by the lines *a*, *b*, *c* in Figs. 34 and 36. The dotted lines in these two figures show the construction of patterns; *h* shows where the arm is cut into rim, *i* is the arm in each figure, and *j*, *k* the ribs on either side.

The core-box for Fig. 34 had better be parted through the centre of groove. For Fig. 36 make the ends of box fast to the bottom, which, with the ends, is made of the same thickness as core print between lines *a* and *c*. The sides are simply flat pieces, and are both loose, as there can be no draft. The outside at *b* is to be left open for both wheels.

Supposing we wish to make a wheel or sheave with a spiral groove on its rim for a rope or wire cable. Such a wheel is, I think, sometimes used with hydraulic elevators to regulate the flow of water by controlling the valve opening.

The pattern may be made in the same way as the pattern for the four-grooved sheave illustrated in my last paper. The core-box is to be so made that it forms the spiral groove. It will be necessary to make but one part of the whole circle for the core-box, the length of this part being governed by the size of the wheel.

Let us divide this core into six parts and let the groove make three turns, then the pattern would be of the same thickness as an ordinary sheave having four grooves on its circumference, and if we have a pattern for a four-groove sheave, of the right diameter, we can use it for this wheel, as the only difference will be in the core-box. Though the casting, in this case, will have some iron in it that is unnecessary, and which might be avoided by a special pattern, let us make one from the pattern which we already have, as this will require only a core-box. Make the core-box in this way: Get out the bottom of a length equal to one-sixth of the greatest circumference of wheel and of the same radius, and the width must be three grooves, plus one groove, on each side, plus the thickness of the two sides of the box. The pitch of spiral will be the distance between the centres of two adjacent grooves.

If we make two lines on the surface of the piece for bottom of core-box, these lines to be located at equal distances from the two sides of bottom piece and distant from each other one-sixth of the pitch, and then draw another line from one end of one of these lines to the opposite end of the other, we shall have a line that will represent the pitch of groove, and all other lines necessary in locating the grooves will be parallel with this pitch and may be laid off from this first pitch line.

The grooves may now be worked out. Get out the two sides of box, fit them to the bottom, cut them to the right width and of the same length as bottom of box. After the grooves are worked out, the ends may be fastened on. Make them as wide as the bottom. Now we must fix the sides of box so as to allow for the change in position of the grooves as they pass around wheel. Let us begin where the groove comes nearest to side of rim. Set off from the outside groove the thickness of outside flange and draw a line through this point parallel with the side of bottom of box. When this line reaches the opposite end of core-box it will be distant from the groove the thickness of outside flange plus one-sixth of the pitch. Transfer this new distance back to the first end of box and draw another line through this new point, parallel with first line. This line will be distant from the first one-sixth of the pitch. Thus we will go on until six lines have been located and drawn all parallel with the side or core-box, not with the grooves.

Then we will draw six more on the opposite side of grooves, and distant from the first six in regular order, just the thickness of core print on pattern, as this will be just the thickness of prints on cores. It is evident that if we set off the thickness of this print from each of the first six lines in succession, we shall get the correct positions for the last six. The first six should be numbered, then number each of the last six to correspond with the number of the line that it is spaced from.

Now, by fixing the sides to each pair of lines in succession by either pins or screws, we can make six cores that will, if we have been kindly remembered by the core-maker and moulder, form a continuous spiral groove, making exactly three turns around the circumference of wheel, beginning and ending with an abrupt, square shoulder and leaving a good deal of iron outside of the groove that is of no use.

Let me first show how to get rid of the square end of groove. Suppose we let the groove make $3\frac{1}{6}$ turns, and let a portion of each end of groove—equal to $\frac{1}{12}$ of circumference of wheel—be tapered off to suit the job.

We shall now have a straight groove—or, rather, three parallel grooves—reaching five-sixths of the distance around wheel. For the remaining one-sixth there will be four grooves, the two outside ones being tapered off from the centre of this part of circumference toward the outer ends.

To form these tapered ends of groove, we may make a special core-box for this segment of core. If there are many castings to make, or where only one or two castings are wanted, we can make these ends in the same box, cutting only one of them into the bottom of box, beginning with the full depth of groove at the end of core-box and running out toward the centre. Then make a piece to fill up this end when not wanted. A little care on the part of core-maker and moulder will make the casting come out all right. Make two cores in the full box, and four with the tapered end stopped off. In setting the cores, put the ends of the two made first, having four grooves, together.

Now, to get rid of the extra iron in rim of wheel, we shall have to make a special pattern, cutting off the rim to the required form, and making provision for leaving the ends of groove in any required form—say we wish to turn the end of cable down through a hole and fasten on the inside of rim.

You will see that the core-box that is to make the greatest part of the core for this pattern may have the sides fixed at a regular distance from and parallel with the grooves, as the cores will all be alike except at the ends of groove. If the groove is to make exactly two, three, or four turns, we will simply have to make a hole in the core-box at the outer end of one of the outside grooves, of such depth as will cut through the rim. One hole will do for both ends of groove. If the groove is to make three and one-sixth turns, we will cut out one side of box for one-twelfth of circumference of wheel—the amount cut away to be regulated by the size of the groove and shape of pattern. Then we must work out the groove in this portion of box, ending with a hole down into the bottom of box at the centre, or finishing the end of groove in any other manner thought advisable. We will want a piece to stop off this extra groove; for the core box, if originally intended to make one-sixth of the full core for a three-turn wheel, would now have four grooves for one-half its length.

For making the last description of wheel we should make two cores from the full box and four cores with extra groove stopped off.

The two full cores, by placing the ends having four grooves together, will complete the three and one-sixths turns to be made by the groove.

It will be necessary for the moulder to exercise a little care in setting the cores, especially in the first wheel, which we made off the regular four-groove sheave pattern, as these cores must all be placed each in its special place except the two cores where the groove begins and ends; here the grooves come central with the rim.

In the last wheel, the cores, with the exception of the two full cores, will go either end first.

CHAPTER III.

MAKING PATTERNS FOR CHAIN WHEELS.

LINK belts are becoming so common nowadays that it is well for every patternmaker to know something about them in order that he may be prepared to some extent when called upon for an effort in this direction.

Link or chain belting may not run quite so smoothly as leather belting, but there is no slipping, and for this reason they are specially adapted to short spaces where gearing is not practicable and where leather belts are liable to slip if the speed is slow. The motion produced is similar to that by gearing. If the diameter of wheels is proportioned to the length of the links or pitch, then the motion will be

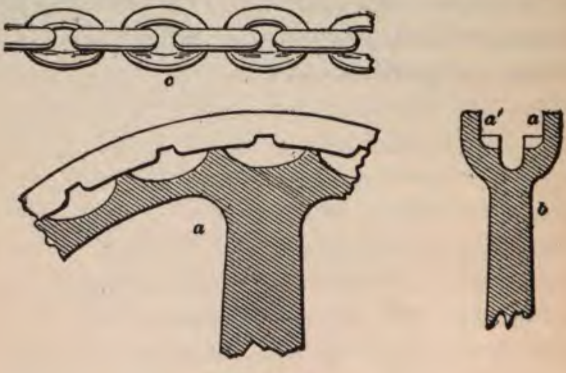


FIG. 37.

smooth and the speed regular. The more teeth the smoother the motion, and *vice versa*.

Fig. 37 is a very common form of a chain wheel, and is made for an ordinary link chain forged from round iron. A wheel for this chain may be made in several ways as regards the position and shape of the teeth or lugs which give the chain a hold upon the wheel. Some forms are made very cheaply, both as regards pattern work and cost of moulding; others, being more complete, will cost more, but to offset this they will wear longer, and also tend to prolong the life of the belt by presenting more wearing surface. The form shown in Fig. 37 is the most complete, and is also the most expensive as regards pattern work. A portion of the rim is shown in section at *a*; *b* is a cross section of same wheel, and *c* is the chain used.

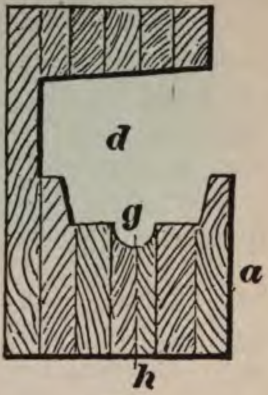


FIG. 38.

Taking all things into consideration, the best way to make these wheels is to form the groove on rim by a core. You may make the core in sections, but usually it is best to make a whole box unless it is a very large wheel.

This box may be turned in the lathe to the shape shown at *d*, Fig. 38. If you make a whole box it should be parted on the line *g*, *h*.

The advantages of a whole box over a segment box are greater accuracy, fewer poor castings, and less work for the core-maker and moulder. It is also better for the pattern-maker, as he is less liable to make a mistake in the pitch of the wheel. The cores will always fit the moulds, while segment cores are very frequently a little too long or too short; this, of course, destroys the accuracy of the spacing.

Perhaps you may think that if the segment cores are made the right length they will always fit the mould. So they would, but after the box is made just the right length, which is not easily done, and in calculating for which you must be acquainted with the core-maker and also the moulder; and in a great many cases where you know the core-maker or moulder you will also know that the cores or moulds get better as the last pay-day gets farther away. After all this we shall still have to take the chances of baking. All joking aside, however, we will allow, as perfection is something rarely attained, that it is easier to get a good job from a whole box. Again, if the core is made in halves they are a bad thing to paste together accurately; and as for the extra work in making the whole box, you will find that the moulder will save the cost of that in making a very few moulds.

I have shown the core-box in section in Fig. 38. It has one side of the print left open all around. The core is rammed up through this opening and struck off level, then by lifting off the part marked *a* the core may be turned out on a plate and dried. The outside edge of print is made with plenty of draft, to facilitate turning the core out of core-box and to make it easier to place the core central in the mould. After our box is turned to the shape shown at *d*, Fig. 38, the next thing is to space it up. The most common fault with all chain and sprocket wheels is in the spacing—the length of the spaces being different from the length of the links. I will try to explain how this may be avoided to a great extent. Measure off a portion of the chain eighteen or twenty inches in length, being very careful to get exactly full links, say ten links are found to be exactly twenty inches long, which makes each one two inches. In this way we reduce any error in measuring the length of a single link into as many parts as there are links in the space measured, on the principle that you can measure a single space with about the same degree of accuracy each time. It makes no difference what the length of the space may be, provided that it is less than the length of the scale or rule used to measure with.

This would ordinarily bring the space within two feet, the length of an ordinary rule. If, then, you could measure a single link within .01 of an inch you could also measure ten links within .01 of an inch, then by dividing this space into ten equal parts we have reduced the error in the length of a single link to .001 of an inch. We should of course measure the chain with a standard rule and then take the same space from a shrink rule before dividing in single links.

The diameter and spacing of this wheel need not be so absolute as in making gear-wheels; still, the teeth in a single wheel should be all alike in order that the motion produced by it may be regular.

To lay out the box we will make two templets, as shown in Figs. 39 and 40. These are made with a gauge piece that is placed against the part of the box that corresponds with the largest circumference of wheel. We will use the one marked Fig. 39 *first, then* with a templet like Fig. 41 we will work out the spaces laid off by 39, which, by the way, will be only every other space. After these are finished lay off the alternate links by templet 40, using a second templet

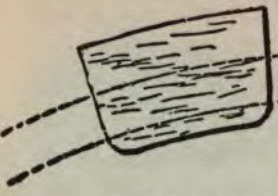


FIG. 39.

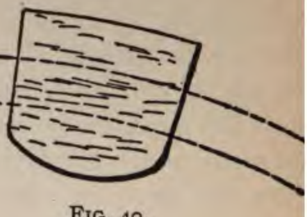


FIG. 40.

like Fig. 42 to gauge the depth of this last cut. This completes the core-box ready for varnish. If there are to be many cores made from this box it will be best to make it of iron, which may be made from either a wood or plaster of paris pattern. In case an iron box is wanted it will be possible to make it from a pattern of only one half or one

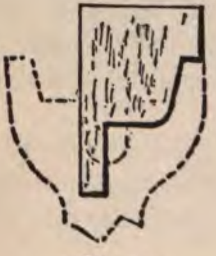


FIG. 41.

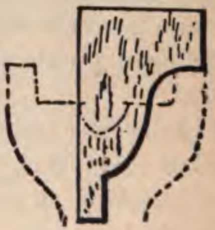


FIG. 42.

side of the rim, by making the upper part of box first, then adding the bottom and outside to pattern before making the second casting.

The pattern should have the rim glued up in segments, with the arms cut in, as explained in my articles on "Cable Pulleys."

A cheap wheel of this kind may be made by turning the core-box out to the size and shape of the chain—by this I mean of such size and shape that the chain will lay in the groove. Then to give the chain a hold on the wheel at every second or fourth link of the chain, two little pieces, *a′ a′*, Fig. 37, are fastened in the box, one each side. These pieces must be of such size and shape that they will go between the links of the chain as it lays in the wheels. This box is much easier to make, and it costs less, but the wheel does not wear as long, neither does it give the firm hold which the other form affords.

[The pieces marked *a′ a′*, referred to in the description of the last form of wheel, using the chain *c*, Fig. 37, are also a part of the first wheel, as will be seen by studying both *a* and *b*.]

There are other ways of making these wheels, but as the two ways I have explained are the extremes, one being the most complete while the other has probably the least work it is possible to get along with, all other ways come between these two, being more or less complete copies of Fig. 37, and need not, therefore, have a special description.

Another form of chain is the one the construction of which is shown very plainly by the two views at *c*, *c*, Fig. 43; the links may be either punched from sheet-metal or cast ready to rivet together. This is a cheap chain, for the pieces are all alike and easily put together.

The pattern for the wheel is also a simple thing to make. The rim should be laid up in segments similar to rim in Fig. 37. This rim has three rows of teeth on its circumference, the two outside rows being placed so that the teeth in one row come opposite the ones in the other outside row, while the middle row has the teeth opposite the spaces in outside rows. The middle row must be made

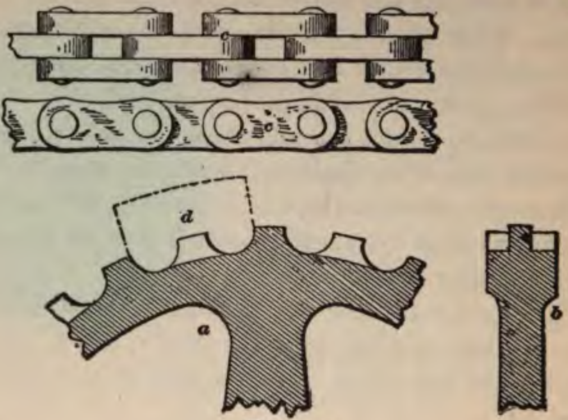


FIG. 43.

by cores, and in turning up the pattern we make allowance for this by leaving that portion of the rim which is covered by this row of teeth wider than the two sides, this width to be such that the cores, which will be described farther on, will not topple over into the mould and cause the moulder to break all of his New Year's resolutions.

The edge of the rim will thus be divided into three equal portions, the diameter of the two outside parts being the same, while the centre has a radius greater than either side by an amount equal to a little more than the depth of the teeth.

We should put a line on each side of the rim, to mark the *bottom* of teeth. The outside rows may then be laid out by a pair of dividers and worked down to central part; this part should then be laid off and cut through, leaving prints, as shown by dotted lines at *d*, Fig. 43. Perhaps a more substantial way of making the prints for the centre row of teeth will be to turn the rim square across and put on the core prints, each one by itself. In this way each single print is formed of one piece of wood, which might not be the case if they were cut out of the rim.

The core-box is shown at Fig. 44, and should be fitted very nicely to the print in order to have the cores stand in just the right places.

This kind of a wheel may also be made in a cheaper form by leaving off all but the centre row of teeth, keeping the rim of the same thickness as the chain, to give it a good support and also to keep it from becoming jammed between the teeth.

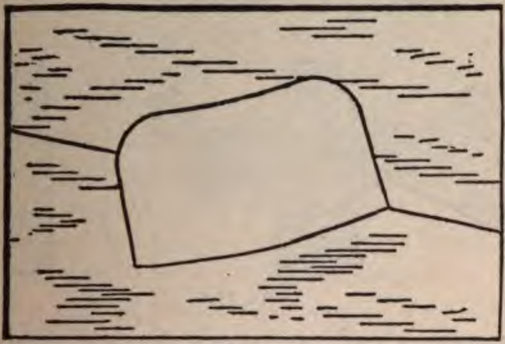


FIG. 44.

There are several styles of sprocket-wheels made with a single row of teeth, one of the plainest of which is shown in Fig. 45, *a* being a section of the rim showing projection of teeth, *b* a cross section of the same, and *c* the chain used. The chain is cast, each link by itself, and then riveted together.

While the chain and wheel shown in Fig. 37, and also the one in Fig. 43, will work equally well in either direction, this one (Fig. 45) is intended to move in one direction only, as shown by the arrow.

In this wheel, as the arms are as thick as the rim, we will let them in part way through the rim, as shown by dotted lines at *d*, Fig. 45, and secure them by nails. The rim should be laid up in not less than three courses of segments, and the teeth had better be put on separately, as, if we make them a part of the rim, we may have bad work when we come to laying and working them out, whereas if we put them on each one by itself we shall have each *tooth* made of a single piece of wood.

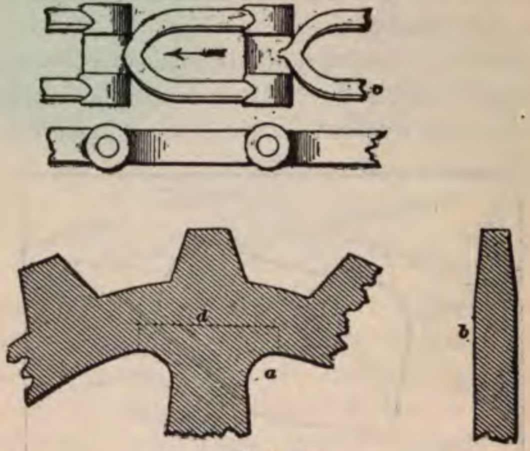


FIG. 45.

CHAPTER IV.

PATTERNS FOR STEAM CYLINDERS.

IT would not be possible for me to give a detailed account of all the different ways of making cylinder patterns and core-boxes. In these days of almost universal use of steam-engines there are so many different makes that it would be quite a task to simply name them all, without going into particulars.

The larger part of slide-valve engines have the same general form of cylinder, with the steam-chest on one side; some are steam-jacketed, and a good many have the front cylinder-head cast as a part of the bed-piece.

In Figs. 46 and 47 I have shown a cylinder of the plain slide-valve type and having a steam-jacket, with the steam-chest at one side and to be fastened to the bed-piece at one end. If it is a cylinder of any size, make the body of staves, following the directions given in Chapter XII, on stave-work. I should prefer to leave the pattern open inside. Some would object to this, because they say the moulders would knock out the heads. Well, the moulder must be allowed some way of working off his excess of muscle, and perhaps swinging a sledge against the heads in a cylinder pattern is as cheap as any other method. If you cover over the joint he will soon make a hole through this covering with his rapping-iron, then the pattern will fill up with sand. Put in the heads so that they will stand a good deal of pounding, fasten on the staves so that the moulder can't knock them off, then he may pound it all over inside without doing any serious damage. You may think that a rapping-iron should prevent all this, but the moulder will rap his pattern where he thinks it will stick the most, regardless of the rapping-irons.

Of course it makes all the difference in the world who the moulder is. Some will pound everything, on principle, I suppose; even the inside of the rim of gear patterns doesn't escape their attention; and still, when you think of some of the patterns they are expected to get good, smooth castings from, perhaps they are not so much to blame. Patternmakers are too apt to throw all the blame on the moulder, who might have made a much better casting if the pattern had been made to suit him. If you are to make a pattern for some new form of casting, better get the moulder's ideas on the subject and tell him what you think about it. Very likely both will be benefited by this interchange of ideas, and you can get a better casting with less trouble all around. Isn't it more to your credit, and also to the moulder's, to get a perfect casting the first time, than only to get it at the second or third trial?

You can't expect a moulder to be over-particular about moulding a pattern which has been constructed contrary to his expressed wishes. It is no more than natural for him to wish for a chance to say "I told you so" when the casting comes out bad. By keeping on the right side of the moulder, and perhaps feeding him a little "taffy"—not too much—we can make the pattern to suit ourselves, and thus get the credit of making the job quickly and also *making* it well, because, don't you see, the proof of the pattern lies in the casting, and the moulder will make the casting. But I am afraid we are getting our moulding done before the pattern is ready.

Let us turn up the body of the cylinder, keeping the size equal to the outside diameter of cylinder, as from *a* to *b*, Fig. 46, and cut in the flanges, giving at least a quarter of an inch depth under the size of print. If the flanges are to be changed, put them on with screws. After the glue has set (that is, if you use any), put the pattern back in lathe and finish turning. I have not said anything about the parting, because the figures show it very plainly—line

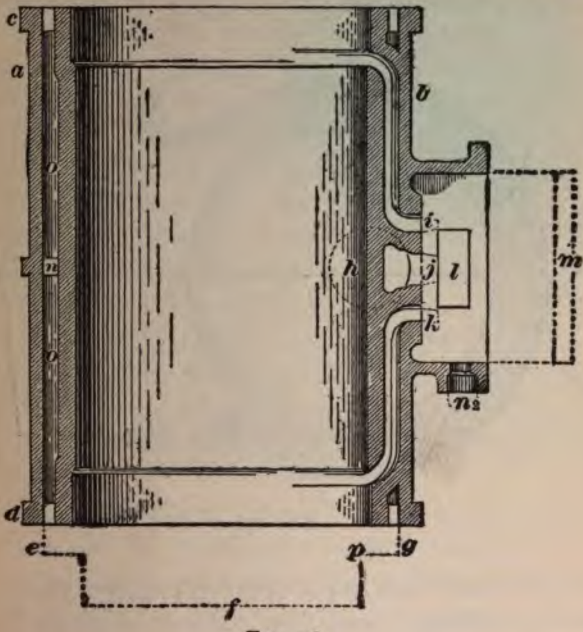


FIG. 46.

m, *n*, Fig. 47. In some cases it would be possible to mould valve-seat down and thus do away with the steam-chest core. Fit on the steam-chest and whatever else there is to put on the outside, screwing everything fast from the inside of pattern. Here, you see, is another advantage of leaving the pattern open. If you covered it over you would have to fasten everything from the outside, which would take more time and not be as good when done.

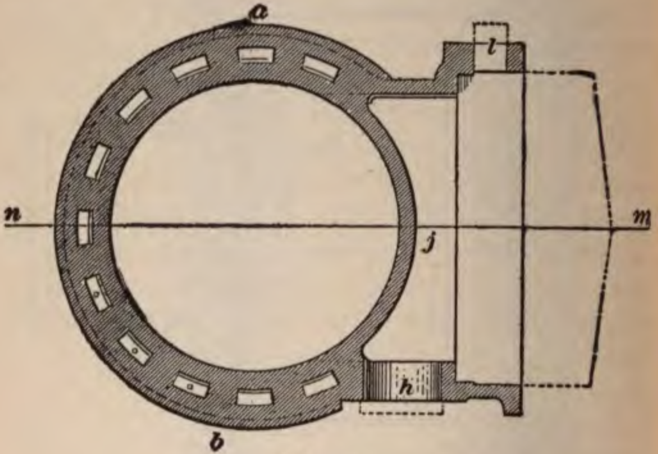


FIG. 47.

You will notice that the core print for steam-chest—broken line *m*—has a good deal of draft on the end. This is to enable the moulder to set this core without disturbing the port cores.

When the pattern is done, give it a coat of varnish on the outside and a coat of paint inside. If the outside is to be left wood color, take pains to keep it clean, else it will look bad when shellacked.

It probably isn't necessary to say that dirty varnish won't make the pattern look any better. If you put on black varnish it is possible to cover up a great many defects. Black varnish is like charity—it "covers many sins."

I like light-colored varnish, both as regards looks and actual worth. It makes a better surface than any colored varnish can, and consequently moulds better. I think, too, that a moulder handles a light-colored pattern more tenderly. If he is one who takes good care of the patterns entrusted to him and gets one to mould that shows good workmanship and moulds nicely (two points which always go together), he will use extra care in handling it; and if he is a moulder who doesn't care, and only works because pay-day is coming, he won't maul a light pattern so much, because a mark on its surface shows plainer and looks so much larger than the same one on a black pattern, and might cause him to lose all interest in the coming of pay-day.

Wherever you put in a screw, counterbore for the head, and then you can plug it up—the hole, I mean; not the head. But don't make your plug endwise of wood for a hole which is bored crosswise. Nails should be set down below the surface and the holes filled with wax or putty.

For a large cylinder, the body will probably be made without a box, so that the only thing we care to know about is the diameter.

The core for steam-chest had better be made whole, for the top and bottom may not be alike, and a whole core is better anyway. The core is shown in Figs. 46 and 47.

The bottom is first made with the valve-seat built on it; also the part of cylinder body which forms the bottom of steam-chest. The prints for steam and exhaust ports are shown at *i*, *j*, *k*. Then the four sides of steam-chest are copied by the four sides of box. Take pains to have this core-box the same length as print, otherwise the port cores won't come right. The top of the box is to be cut to match the draft on pattern. The four sides should be fastened together by screws; then after removing the screws you will perhaps find it a great help to draw each side away from the core by itself. It will enable you in a great many cases to do away with loose pieces, which you should always strive to avoid, as they are a perpetual bother. Give the prints for steam ports plenty of draft, so that they may draw clean and also make it pleasant for the moulder in setting the cores.

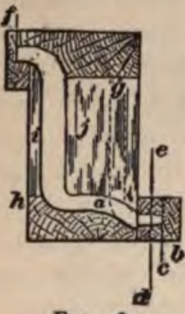


FIG. 48.

Now the box for port cores. If the ports in valve-seat are located centrally on the body of cylinder, and the steam ports are alike on both sides, one box will do for both cores. This box I have tried to show in Fig. 48, although in this case it would be necessary to have two boxes to avoid cramping the exhaust opening. The core is given an extra crook on the lower side to give the exhaust more room. To make the box, get out the top *j* from *g* to *a* on a radius equal to diameter of cylinder, plus thickness of body, plus thickness of core. Then the bottom *i* on a circle the thickness of port core less, making a joint at *g* in top and at *h* in bottom. The rest of the box is put on the opposite way of grain of wood, as plainly shown in the figure. This avoids the short grain you would leave at each end if you attempted to make the box all one way of the wood. You must be accurate in the dimensions of this box, else the core won't fit. The end of box next the cylinder should be cut to the circle of main core as may be seen by Fig. 47. The steam-chest end should have the prints formed to closely fit the prints on valve-seat. Care should be taken in laying out these core-boxes, also the exhaust core-box, to keep an even thickness of metal all around. This core-box is to part at *c* and *f*. The print end of this box shows at *c*, where finish is to be left in port openings to admit of squaring them up. The line *e*, *d* is face of valve-seat with finish added. The broken lines *a*, *g* show the shape of core through centre of box. This form is also shown in Fig. 46.

You may have to make two boxes, or two halves of two boxes, if the openings in valve-seat are not located centrally on cylinder. This is not usual in slide-valve engines, but in vertical cylinders for marine engines with oscillating valves it is quite common, and for these the port cores are generally made in halves with the joint in same plane as joint in pattern. The box is built on a flat board which forms the outside edge of core, and the sides of box are cut

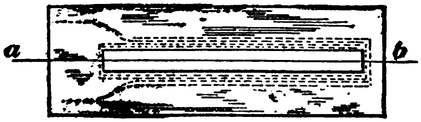


FIG. 49.

through where the core runs parallel with the body of cylinder, usually at the outside end as at *g*, Fig. 48, so as to leave a piece of a length equal to the difference in length of the ports. This piece fits both ends and enables the core-maker to make the half-cores in pairs. The two port cores, the exhaust core and steam-chest core, are all made together for this form of cylinder.

The exhaust core is another crooked box to lay out. Starting from the square opening in valve-seat, it goes down to body of cylinder, increasing in width toward the opening into pipe. This core is generally calculated to remove all superfluous iron between valve seat and body of cylinder. I have shown this core in section across the cylinder in Fig. 47; also a section lengthwise of cylinder is shown in Fig. 46, and a view parallel with valve-seat is given in the figure of exhaust core-box, Fig. 49. This is a top view of exhaust box, the broken lines showing the shape of core as it goes down toward cylinder and increases in width toward the discharge at *a*, Fig. 49. This box parts vertically on line *a*, *b*. You should have a print on the outside of steam-chest to receive the end of this core, as shown by broken lines *h*, in Figs. 46 and 47.

After you have completed these port core-boxes you will probably agree with me in saying that they are a crooked job, and also one that to a certain extent shapes itself, for the steam ports must not offer any unnecessary resistance to the passage of the steam, and they must be kept close down to the body of the cylinder, that the cylinder wall may also form the wall of port. The steam port must also be kept out of the way of exhaust. In short, these *three holes* are to be kept as closely together as possible, and must have an even thickness of iron all around to insure a good casting.

If your cylinder is to have a steam-jacket as at *o*, *o*, *o*, Figs. 46 and 47, there is also a box to be made for this core. Probably the most common way of supporting this core is shown by broken lines *e*, *g*, Fig. 46. The square holes *o*, *o*, *o*, Fig. 47, form the connection between the jacket cores and the prints for same. This jacket core is made in two, four, six, or eight parts, according to the size of cylinder, so that the cores resemble staves. Provision must be made in this box for the passage of steam and exhaust ports through steam-jackets, for connecting cylinder cocks, and for supports between body of cylinder and jacket, as shown at *n*, Fig. 46; also for any other points where the jacket core must be cut away.

Make the box for whatever part of the full circle you wish, to the radius of outside of core, and put sides on the box of a height just equal to the thickness of jacket core. The ends must be as high as thickness of print, from *g* to *p*, Fig. 46. The inner surface of core to be made by a sweep, resting on and guided by the top of ends.

You will also want a box for steam opening in steam-chest, at *l*, Figs. 46 and 47, and a box for stuffing-box, where valve-rod enters steam-chest at n^2, Fig. 46. The print at *l* should be long enough to balance core, otherwise the shape of core is plainly shown in the figure.

For very small cylinders I would make the port cores, exhaust core, and steam-chest core, and possibly the body core, all in one, in order that all of the cores should come in the right places.

The cover for steam-chest is not a very difficult pattern to make; the trouble lies in keeping it straight after it is done. It is evident to any one that a flat piece of wood in the shape of this pattern is very liable to warp. The common way of preventing this is to screw on some pieces across the flat side; these are to be stopped off by the moulder. A better way, and one that is usually successful, is this:

Select a good piece of lumber 1½″ or 2″ thick which has no shakes and has kept flat and straight while drying. Saw this board into strips of a width equal to thickness of stuff you will need to get the pattern out of. The stuff should be dressed down flat and straight before sawing up. This makes all the joints much quicker than could be done after the stuff is cut into strips. Lay the strips down side by side in the position they occupied before sawing apart. Suppose them to be numbered 1, 2, 3, 4, etc., beginning at one edge of the original piece. No. 1 will be the first strip cut from the edge; place 2 on top of 1, then 3 on 2, and 4 on 3, and so on to the end. Glue them together in this shape, and you will have a piece of stuff that will keep straight in places where the original board wouldn't stand at all.

After this piece has been dressed to the right thickness put on the strip which forms the extra thickness of cover around the edge. When this piece runs across the grain of the first piece don't use any glue, because, when the first piece swells or shrinks, if you have glued anything across the grain it will tend to prevent that side from shrinking or swelling with the rest of the piece, and when a board shrinks or swells more on one side than on the other the board warps. So put on whatever goes across the grain of a pattern like this with nails, thus allowing the board to come and go, which will tend to keep it in better shape.

This manner of constructing the pattern is for a cover which is simply a flat piece of iron. If it has ribs running across it perhaps these may be in such shape as to keep it flat without any further precaution.

The valve shown in Fig. 50 is a plain *D*-valve, and can be made to leave its own core by making the pieces which form the shoulder at *c*, *c* loose. To make the pattern, get out a piece of stuff having a section like *a* and long enough to go way around the pattern at the lower side, then you can mitre the corners and glue the whole together on a flat surface. After the glue has set, nail the joints. Get out the piece which is to form the face, leaving the parts marked *c*, as they must be loose.

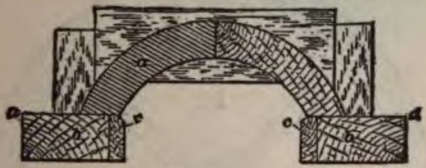


FIG. 50.

This part forming the face had better not be mitred at the corners; cut the sides between the ends, thereby cutting a gain in the side pieces. The loose pieces will be held in place by the tenons and shoulder. If this loose section extends all the way round, leave a good shoulder as at *c*, then mitre the loose pieces at the corners, then when all are in place they will support themselves. In case it is considered best to make this pattern with a core for the inside, I would make it *solid*, putting on a print at the bottom about ½″ thick. Make the core-box with a joint at the upper edge of flange on line *d*, *d*, not forgetting to put a piece in box to form that part of the sleeve for valve stem which shows on the inside of valve. The core prints for the valve stem should be carried down to the body of valve and given plenty of draft, then make the core-box so that the core will fill up the prints.

The piston, as I have shown it, is made all in one piece and cored out. This, I suppose, would be condemned by some builders, who would prefer to make the piston in two parts and bolt them together, which would also do away with the necessity for a core.

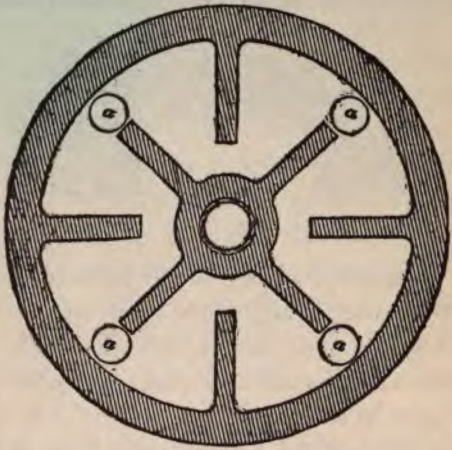


FIG. 51.

Glue up the ring to form pattern in cants or segments, cutting the heads into the ring on each side, turning a recess to receive same, and putting in some pieces across the grain *of heads,* between them, to support them. Now put on four prints to support core, placing at points marked *a* in Fig. 51.

If the supporting partitions in casting are put in in the shape I have shown, the core will be all in one piece, and can be supported by four prints, as I have shown. If the partitions are carried completely across, thus dividing the core into segments, then each segment must be supported by from one to three prints. As the holes made by prints in castings have all to be tapped out and plugged, the fewer holes the fewer plugs to fit in.

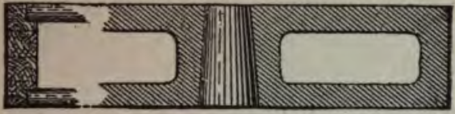


FIG. 52.

Make your core-box by building up a ring in cants on a good bottom piece which is thick enough to get in the length of prints. After the ring is turned out, space off and cut the four holes which will form the prints on cores. Then fit in the radial ribs, as shown in Fig. 51, and your core-box is done. Fig. 52 is a section of piston.

If the core is divided by ribs into segments the core-box will also be only a segment of the whole core. The hole for piston-rod will require a core-box.

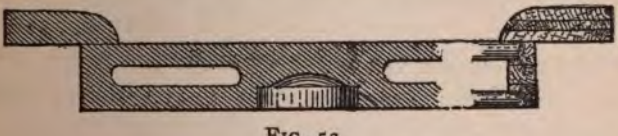


FIG. 53

The cylinder-head, Fig. 53, should also be glued up in cants, putting the inner side next face-plate. In gluing up, and when you get to the right height for putting in the outside head, turn off the face of cants, cut a recess to receive the head, and, after fitting it in, glue on the flange in three courses of cants. I always try to put not less than three courses of cants in any piece for a pattern, as one course is really no better than a ring made of one piece, and two courses won't stay in shape, therefore three courses is the least that you can put in and make a good job.

This cylinder-head is shown cored out in the same shape as piston. The prints for supporting core will probably be located on the inner head, and the core box should be made in the same way as box for piston. If the cylinder is a part of a tandem compound engine, the head would have a stuffing-box and gland for rod connecting to the other piston.

The gland for stuffing-box on steam-chest for valve-rod will require no explanation.

CHAPTER V.

ONE WAY OF MAKING A CROSSHEAD.

I WAS going to tell where the pattern shown in the figures was made, but I will leave that out and only say that I was given the pattern to make from a blue-print of the finished piece, and was given all instructions necessary as to finish, core prints, etc., and was also told that it was to be made in a three-part flask.

Although there had been other sizes of the same piece made, which I had seen in a general sort of way, I couldn't for the life of me tell how it should be made for a three-part flask; but I could see very plainly how it could be moulded in a two-part flask, and after some further talk it was agreed that it should be so made.

It was required to mould the flanges *a*, *b* down to keep them as free from dirt as possible. The centre pin was to have a hole cast through it, for oiling, I believe. The piston-rod socket was to be cored through, as shown by *d* in Figs. 55 and 56.

Fig. 54 is a section through lines *j*, *k*; Fig. 55 is a section through *g*, *h*, Fig. 56 a section through *e*, *f*, while Fig. 57 is a section on lines passing through rod end. The letters refer to similar parts in all the figures. Outlines of core prints and partings are designated by dotted lines.

Get out the two flanges *a*, *b* to the width shown in Fig. 54 at *i*, and across one end—the end toward cylinder; fit a piece having a width equal to the distance from *l m* to *n*, Fig. 56, and thick enough to reach from the lower side of flanges up to the centre line *e*, *f*, Fig. 54. This piece should be long enough to reach across the flanges, and should be cut into them half their thickness. The side of this piece toward centre pin is then to be cut away, as shown by dotted lines between *d* and *n* in Figs. 55 and 56.

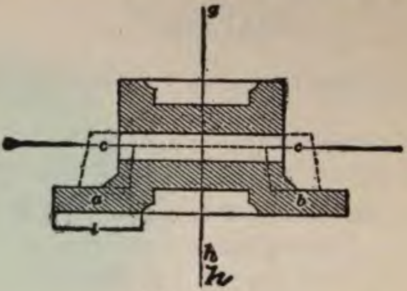


FIG. 54.

The sides of the crosshead are then gotten out and fastened together by that part of the piston-rod end of pattern which is inside the end of flanges at *l*, *m*, Fig. 56. This piece must be fitted into the recess cut in lower half at *n*.

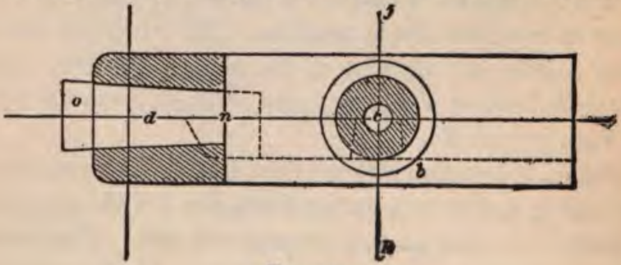


FIG. 55.

The sides must be placed a little further apart at the top than the bottom, to make the pattern draw nicely. Don't make too much draft as it will make trouble for the moulder in cutting down to centre of pin, and also make the casting look bad. The outside of side pieces may be nearly square. Now get out some fillets as are shown above *a* and *b*, Fig. 54. They should be made of hard wood in order to preserve the edge which meets the flange, and is liable to be broken off, as the parting is made between the fillet and the flange. The fillet is made in the shape shown for the same reason.

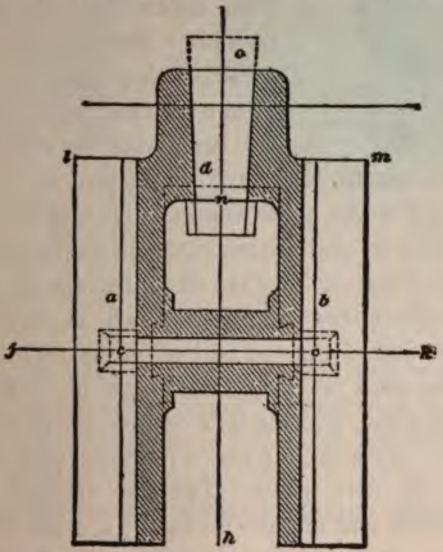


FIG. 56.

Then the centre pin *c* is turned up as a split-pattern, the facing pieces, which also form the shoulders at each end of pin, to be made separately and in halves. Their thickness must be such as to allow for the draft on side pieces. Here is something that it will pay to remember: If we make the draft on these shoulders, from the pin to their circumference, equal to the draft on side from centre line *e*, *f* to the top, then after these pieces are fastened to sides they may be planed off square with the centre of pin without destroying the draft, and thus making it easy to cut in the centre pin, and it makes a neat job. The dovetails shown each end of centre pin should be cut through to the bottom of flange and well fastened to the flange, as they are all that keeps the lower half of pin, to which they are also fastened, in place.

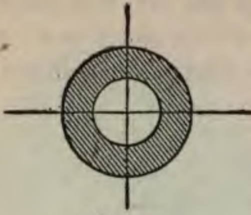


FIG. 57.

That portion of the rod end of pattern which projects beyond the ends of flanges may now be turned up and fastened in place, making it in two pieces, parted through the centre. This pattern needs no dowel-pins and is now ready for the core prints. The one marked *o* may be made with the end of the crosshead; the one at *n* should run down to the parting at top of flanges or wings. The prints at each end of centre pin should also run down to the flanges.

This looks like a crooked piece of work, but in reality it is very easy to make, and the moulders were very much pleased with it, and consequently the casting looks slick and clean; in fact, all the sizes which had previously been made for three-part flasks were sent for and changed to *mould* in the way I have shown.

There are two core-boxes to make for this job. Fig. 58 is the box for piston-rod socket, and is tapered as shown, with a recess at one end—the smallest end—that the core may fill up the print in mould. Fig. 59 is the box for centre pin. This box has a recess at both ends to fill up the mould. Don't forget to leave a corner at *a* in both ends of box corresponding to a section of the fillet between sides and flanges, thus making the core so that it will leave intact the fillet between sides and flanges on casting.

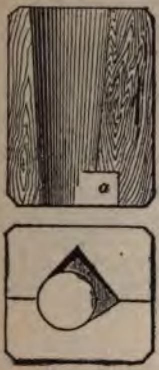


FIG. 58.

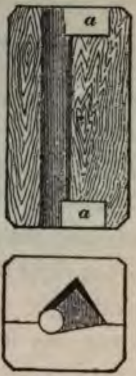


FIG. 59.

CHAPTER VI.

MAKING GEAR PATTERNS.

WE sometimes get the whole design to work from; then we have smooth sailing, because we have comparatively no responsibility beyond what we have in the construction of all patterns. When we have given us the pitch, number of teeth, and are expected to furnish the rest, if the casting comes out right the "boss" gets the glory, and if it doesn't come all right we must shoulder the blame. Isn't that about the way it works?

As we always find out the size of tooth first, we have that to start on. Now let us make the rim with a section equal to section of tooth at pitch line. Give it plenty of draft (one side must cope out, you know), and add the rib inside rim, shown by Fig. 60 in section. The arm I should make straight and with a rib on each side, having a smaller section than the rim, Fig. 61; then let the arms taper to a size at the hub that will give them the same strength in proportion to the strain as the outer end of arm. The arm is to be of the same thickness as rib shown inside rim.

The edges of arms and the rib inside rim are not rounded, but the section shows a point. This gives the moulder a guide for the parting, and the casting will look better than when the moulder puts on this edge.

Commence with the rim, so regulating the thickness of courses as to have a joint come up to the top of arms. After this course is on, turn up the rib as near the finish as possible. In the time between courses, and as it is best to wait for the glue to dry, and not use nails, right here let me say that it is nearly always possible to wait for the glue to dry in laying up courses.

There is on most jobs other stuff to get out. If your glue is right and the weather is right, you need not wait over thirty minutes for any job. I have faced off a course that had been on only ten minutes, and didn't put any nails in the glue either. Next get out the arms.

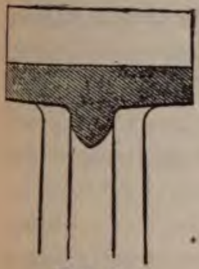


FIG. 60.

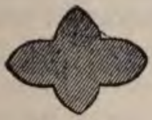


FIG. 61.

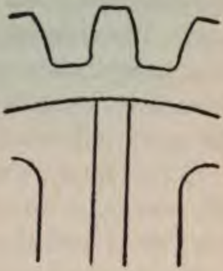


FIG. 62.

If the arms are pretty heavy and of an even number, and you think best, you may lock them together. I wouldn't do it, for I don't think it any improvement, unless it is a case where it is impossible to fasten the hub on one side. I should butt the arms together, glue them, and screw fast to lower side of hub. Cut them into rim, leaving enough wood outside the ends to make it substantial.

I know that some may object to putting in the arms permanently, for the reason that they may wish to put in a heavier or a lighter set; but if the arms are properly proportioned, they are not only the most suitable size, compared with teeth, but are also of the right size to make a good casting. If they are made larger or smaller, there will be a strain that will tend to weaken it, and perhaps draw it out of shape.

Better make the arms straight. Crooked arms don't look as well and are not as strong. Some set the arms as tangents to the hub. This, they say, gives them a chance to relieve the strain of unequal shrinkage by twisting the hub. The arms may be straight, and the shrinkage won't hurt them if they are made by a good moulder. If the arms don't come full up to the top of last course, fill up the space with wood, then finish gluing up the rim.

In turning the rim, be careful not to cut the arms half off, because it would weaken them, and don't re-chuck your wheel until the teeth are fastened on.

We are now ready to put on the teeth and will make up our minds as to how we do it. The oldest way, perhaps, is to put in dovetails, and the best I can say for this method is that we should always respect age. We are not obliged to do as our fathers did. I know of one firm that uses a good deal of gearing and they won't have any dovetails. They say that it takes too much time; besides, it is liable to spring the rim. I agree with them as to the expense, and I would just as soon have them put on in some cheaper way. In fact, where it is possible, I would just as soon have them put on solid with glue.

I presume the idea of using dovetails was originated to overcome the difficulty of drawing the teeth all together. If one tooth stuck, the moulder could draw it by itself.

If you had made your wheel so that the teeth were not parallel with each other, the moulder would be able to draw them one at a time in different directions, as circumstances demanded, and so he would be able to mould your wheel. As to the value of casting, I won't say, because the patternmaker might be near. Again, if the patternmaker is competent to make a pattern so that the teeth and dovetails are in line, isn't he capable of making the whole wheel so that it will draw all together?

Perhaps it will take a little longer to work them if they are glued fast, but it will save time on the whole. I can work the teeth about as quickly as I can put in the dovetails. If they are glued on it holds the fillet at root of tooth. Another way to save this fillet is to put them on like Fig. 63, using dowels and screws.

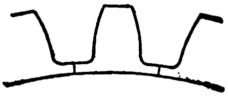


FIG. 63.

I have put on teeth with screws alone. If you should try this way, don't forget to mark with a knife across the tooth and rim at each side of wheel before taking them off to work, and you will need to be very particular in replacing them or you will destroy the spacing.

I should use two dowels and one screw for anything under 6″ face; above that use more screws. Somewhere I have read or heard about working teeth in long strips, cutting them up to length and nailing them on. This method is only excelled by the man who saws them out of the solid wheel and finishes them with sandpaper. Both ways might suit some people. There is no accounting for tastes.

Having the teeth fastened on, finish trimming and mark the pitch line. Don't make a line a sixteenth of an inch wide, but first get a good surface by means of shellac and sandpaper. Then, using a fine, sharp point, make a line as fine as possible, taking your eyesight into consideration. If you want a line for centres, make that also in the lathe.

Now you come to what I consider the most important part of the whole job, spacing round the wheel. Don't try to do this without first putting a fine, sharp, *round* point on each leg of your dividers. A three- or four-sided point won't work well, and if the point is not central you cannot space twice around your wheel and come out the same. I think a pair of dividers with movable points best, because you put these points in the lathe and sharpen them up nicely. Don't use a pair of dividers that are too small, because the points will stand at an angle so great that it will vary the spacing.

You may test them as follows: Step off two or three spaces (to get the motion) on any straight line, then before setting down the point for the next space mark a short arc; step once more and move the dividers as if for another step, but simply make the point mark the space, then, turning back once, strike a second arc through the point occupied by the first arc. If the two arcs just touch without intersecting, your dividers are in good shape, and are large enough. If they are too small the arcs will nearly always intersect.

Space round your wheel, being careful to set the points down exactly on the pitch line. Don't bear on too hard—just enough to keep the points from slipping. How did you come out? I have been so fortunate as to come out right the first time, but this doesn't occur very often, I am sorry to say.

If you come pretty near it, perhaps you may correct the space by giving your dividers a rub on the oilstone. If you fall short rub them inside, and if you overrun rub the outside.

I have always been foolish enough to correct the space by means of the spring and screw which are found on most wing dividers. I presume I have been obliged to space four or five times around the wheel, when I might have struck it right the first time by resorting to the oilstone, but after I get good points on my dividers I am anxious to keep them so, and I have always been able to come out right by means of the screw.

In spacing a rack, don't try to set the dividers exactly by a rule, but supposing the pitch is 1½″, measure off a foot exactly, and then make your dividers cut it up into eight spaces. I suppose that you can lay off a foot with no greater error than you would in laying off 1½″, and the error would be divided into eight parts, so you would get your 1½″ laid off only one-eighth the original error too large or small.

Another thing I do is to leave off the centre mark on each tooth. Make your spacing marks where one side of the tooth is to be, then by setting off the thickness of the tooth you have all the points necessary.

Perhaps I needn't tell you not to alter the dividers you set off the pitch with until you have spaced all the wheels of the set on both sides, if they are spur-wheels; for bevel wheels it doesn't make so much difference, because they may be corrected in fitting up. If bevel wheels are laid out on both sides of the teeth and worked by these lines, they will be wrong in ninety-nine cases out of a hundred, and the one other which comes right is only a streak of luck.

You must be very particular in squaring across the face of spur wheels or the two wheels will touch on but one side. Don't trust to a try-square, but lay your wheel on a flat surface and use a right angle, and after making one mark turn the angle round to the opposite side and make another mark. If the two lines are not parallel, the right line will bisect the space between the two.

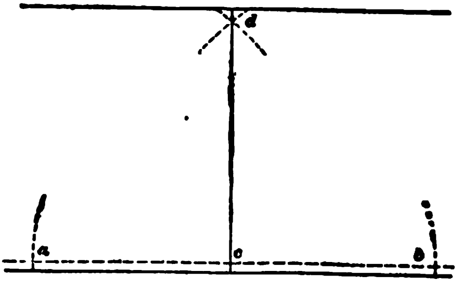


FIG. 64.

There is another way of squaring across which works equally well for spur or bevel wheels.

If you have no flat surface large enough to lay your wheel on, you may square across by the method shown in Fig. 64. Let the figure represent a portion of the circumference of wheel, *c* the point you wish to square from. With a gauge, mark the line *a b* as near one side as you think will support your dividers. Taking *c* for a centre, strike two points *a* and *b* with the same radius. Using these points *a* and *b* for centres, strike the arcs seen at *d*. Now a line drawn through the point *c* and the intersection of the arcs at *d* will be square with line *a b*. This method is equally good for bevel wheels, but for these it is better to use the instrument shown in Fig. 69.

For the draft $\frac{1}{64}''$ is sufficient for 6″ face; this makes the tooth $\frac{1}{32}''$ smaller on the bottom and the space that much larger. The clearance is governed by the pitch and the place the wheel is to occupy. A very good rule for the clearance is to take $\frac{7}{15}$ of the pitch for the tooth and the remaining $\frac{8}{15}$ for the space, making the tooth the draft smaller.

Draw lines across the top of teeth at every tenth or twelfth tooth and test them to see if they are square.

Space around with the same dividers you used for the first side, as the pitch circle should be of the same diameter on both sides of the wheel. It is a pretty good test of your skill in spacing to make the spacing come out right without any alteration of the dividers.

Now you want a stiff pair of dividers to lay out the teeth after locating both sides of the tooth on the pitch line. In marking the outline of tooth turn your dividers in the same direction for every tooth, and don't bear on too hard. If you have first made a good surface with shellac, you will be able to see a pretty fine line. If you work with sharp tools, you don't actually need a line any wider than the edge of your tools. This would not be visible, so we will make it just wide enough to be visible.

If you take off the teeth to work them, you will very likely be able to plane them out. Don't try to make the fillet at root too thin on the side next the rim if the teeth are not glued on. Unless you make the fillet like Fig. 65, instead of trying to make the full quarter of a circle you had better leave it off altogether, for you will make a bad job with too much feather-edge when you strike a tooth that is a little cross-grained. Some makers never put in any fillet, but I think that it not only strengthens the tooth, but also makes it easier for the moulder. It is very hard to prevent a sharp corner of sand from wasting.

The fillet shown in Fig. 65 gives an exaggerated example of the kind. In practice I should make them much nearer to the quarter circle.

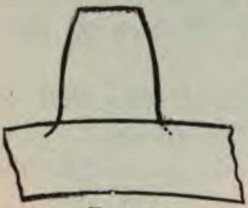


Fig. 65.

In working the teeth, don't leave all of the line on one side and cut it all off on the other, for this is wrong and makes the same trouble that uneven spacing causes.

As I have said so much about uneven spacing, let us experiment a little and see how a pair of wheels which are spaced badly will work. Let us first locate the bad places and number them like this:

1. A thick tooth. This makes the space on each side, or it may be all on one side, small.

2. Three or four short spaces, where you crowded the dividers a little, to make the spacing come out right (?).

3. Two small teeth and a large space between.

These faults are in the pinion or driver. In the driven wheel we find one very thick tooth. (I have seen a case so bad that the spacing and working together had made a difference of $\frac{1}{16}''$ in the thickness of teeth at pitch line.)

The two wheels are fitted up and ready to run. Turn them slowly around and notice how the teeth mesh together. *(In this* case it would be more appropriate to say "mash.")

No. 1 is on the line of contact and is the only tooth that touches, and will be until it is worn off to the correct size. No. 2 starts in and crowds the driven wheel faster as each of the short spaces comes up to the work, but if you look sharp you will see that each succeeding tooth takes all of the load upon itself, pushing the opposite wheel away ahead of the preceding tooth. This will make the wear on this part of the wheel excessive and will give the driven wheel an uneven motion. It will also tend to throw the whole error on the first correct tooth, and if that big tooth on the other wheel should strike one of these short spaces I presume something would break. You didn't notice that big tooth when it went by, because it went into the large space, No. 3. If you will figure how many revolutions it will take to bring it into contact with the short spaces, you can tell about how soon you will be obliged to put in a new wheel.

One way to help this uneven spacing is to give lots of clearance. This may be done in the pattern, or perhaps some kind-hearted machinist or millwright who sets up the job will spread the wheels so far apart that the only danger will be that they may slip out of gear.

Another way is to cut the teeth similar to the teeth of a cross-cut saw. It would be almost impossible to break a tooth of this form; but the bearings of the shaft would require a good deal of attention and grease, I think.

After you have worked off the teeth without spoiling a single tooth, and each and every one is cut right to the centre of the line, you will be pretty apt to think that you have got a good job. So you have; but let us try them with a pair of calipers, or, better still, with a gauge. Cut a piece of hard wood, ½″ thick, like Fig. 66. After making the distance from *a* to *b* equal to the depth of tooth below pitch line, saw from one side two thin pieces. These may be used as calipers by putting on a small handscrew. You can take two teeth and one space, or by turning the pieces both the same way you can take one tooth and one space. Don't be discouraged if the gauge shows a variation in the sizes of teeth and spaces, for this is the common failing and the greatest fault of cast gears. It may, and probably will, be only a slight variation.

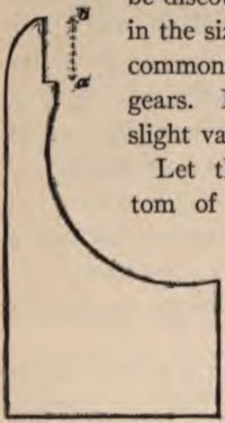


FIG. 66.

Let the end *b* of the gauge go to the bottom of the space. Then if you find the teeth and spaces are all equal, you have got a good job. Be careful not to spoil it by sandpaper and varnish. Use a stick planed to fit the tooth for sandpapering, and put on the varnish very thin.

This wheel will make the moulder happy, and produce a good casting if one good moulder does all the ramming.

If two or three moulders each ram up a part of the mould, you will probably find as many different sizes of teeth on the casting as there were moulders on the mould. This is nothing to the discredit of the moulders, who may all be good men, and still there will be a difference in their work. Any one of them would produce a better casting alone. But we will let the moulders make their own mould; we have done our part of the job.

In regard to the hub: I depend on the lower half to hold the arms together, and as the hub is generally deeper than the rim, if it is made fast to the spider it will be in the way when you wish to lay the wheel on a follow-board to mould. To remedy this, and at the same time support the arms in moulding, I cut the hub off even with the rim. The rest of the hub is loose with the core print. Make that part of the hub which is fast as small as you will ever want for a hub on this wheel. When you want a larger hub, fit it over this piece.

When making calculation for the clearance of teeth, you had better get the moulder's ideas on rapping patterns, for you may find it necessary to allow a little more clearance to enable him to get in his ideas on the subject.

In allowing draft on the teeth, remember that a mould will usually strain a little at the bottom. This, of course, will make the casting have less draft than the pattern.

SPIRAL AND V GEARS, AND WORM-WHEEL PATTERNS.

I am aware that it is the usual custom to true up the teeth of V gears to a straight-edge, or sometimes by a bevel, which is worse yet, because it is impossible that the tooth should be correct and have a fixed bevel fit it at more than one point on the face.

Did you ever try to grind a plane-iron on a stone that was cut down low in the centre? Well, in trying to get the edge straight you had to hold it at an angle with the side of stone; then doesn't it follow that you would grind the iron hollowing if the stone had been true and you still held the iron at an angle? In the last case, would not the edge of the iron be the same as the line formed by the intersection of the face of a tooth, placed at the same angle as the iron was held, and the rim of the wheel or pinion? Does not this show that you cannot true up the teeth by a straight-edge? Now, I propose to illustrate a way of getting around this difficulty in, as I believe, an original and accurate manner.

Let Fig. 67 represent half of a V-gear pinion of these dimensions: 2″ pitch, 6″ face (the Fig. is 3″ face); the angle or depth of V 2″. These dimensions are simply to save time and ink. To avoid confusion only one tooth is shown.

After the teeth are turned up and laid out on both sides (by the way, mark the centre in the lathe if you haven't already, and drive a wire nail in both sides), then make your template as follows: You will need a piece of stuff 5″ long, 4″ wide, and 2″ thick. Plane one side flat as *f*, *g*, *h*, then cut the block as shown by broken lines, making the curved side with a radius equal to radius of pitch line on pinion, having the edge *f* in a radial plane. Then make the piece *k* 1½″ wide, ½″ thick, and 3″ or 4″ longer than from the centre to top of tooth. The edge which is to be placed against the pinion should be beveled so as to touch the wheel only at the side next *c*.

This should be fastened to the block already made by screws nicely fitted, so they may serve as dowels. Place the thin edge of *k* and the curved side of the block at right angles. After the right position has been fixed by the screws mark across the block along the beveled edge of *k*, then remove *k*, and draw a line across the curved side of block to meet the line across the edge *f* and square with *f*. Make another line parallel to and 3″ away from this first line. Lay off on second line 2″ from *f*, and draw a true spiral line from this point to where the first line meets *f*; work off the block to this line, which will be practically

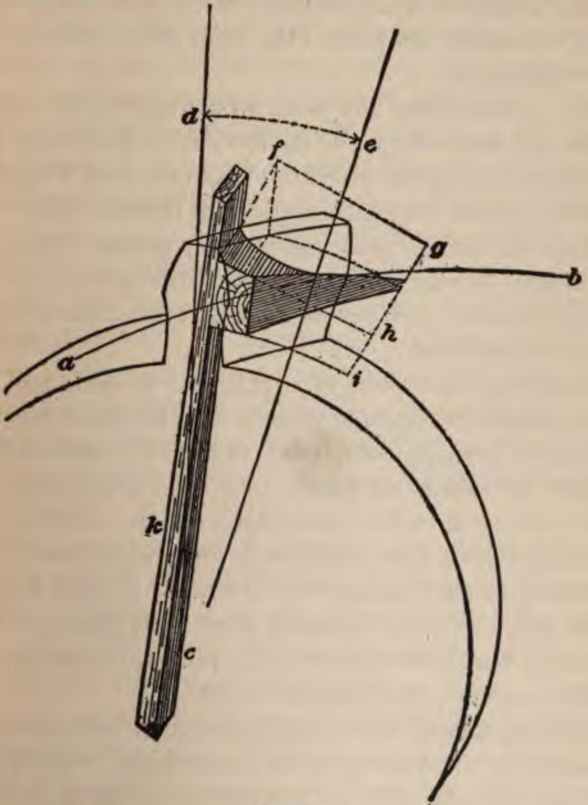


Fig. 67.

like the edge of plane-iron when the stone was true, shown in the figure by the curved line *a b*. The rest of the block may then be cut away so that it will go between the teeth, only being careful to preserve the angle on line *a b*. This line, in my opinion, is the correct shape of face of tooth at pitch line.

The template will of course be correct only at pitch line, being a little too full toward the point and a little too flat nearer the root.

For a worm-wheel the block would have to be curved on line *g h* to fit worm. If the teeth are to be formed in a core, place a temporary centre to hold the arm *k* against. If a large wheel with arms, better put them in before you turn up the teeth to guard against any possible change in the shape of wheel. You always work exactly to the centre of a line. So if you would do an exact piece of work, get your lines exact.

Sometimes one wheel of a pair gets broken, and the patternmaker has nothing to work from but the remaining wheel and, perhaps, the number of teeth in broken wheel. In order to make a new pattern, it is necessary to know the pitch, number of teeth in each wheel, and the width of face.

If it is known how many teeth the broken wheel contained, figure the diameter by the number of teeth in each wheel and make your drawing from those figures. The bevel will remain the same for any pitch if the number of teeth in each wheel remains the same.

If the number of teeth is not known, then very carefully measure the wheel to be mated at the point of teeth *a b*, Fig. 69. Lay this down; then take the width of the face with your dividers, and from centre *a* describe arc *c d*. Next, take the diameter of inner points of teeth as on line *e f*. Draw a line from *a* through the point where this diameter intersects the arc *c d* as at *e*, and continue it to the centre line of wheel *r*. This will give the bevel of top of tooth on the wheel to be matched. To get the bevel at pitch line, and also the diameter, strike from *a* another arc with a radius equal to half the working depth of tooth. This can usually be determined by the wear on teeth, or perhaps by the dirt and grease which has been rammed into the bottom of space by teeth on opposite wheel. In the cut, the radius of this arc will be the line *a h*. Draw a line through *h* to the point *o*, which is the centre of the pair of wheels; then draw another line at right angles with *h o*, and passing through *a*. Then will the intersection of these two lines at the point *h* be the pitch line of the pair. From *o* draw line *o i* to show the line of shafting to which the required wheel is to be fastened. This may not always be an angle of 90°. Draw another line from *h* to *o i* and at right angles with *o i*. This will be practically the radius of required wheels, but may be further corrected by the pitch as found by diameter and number of teeth in opposite wheel.

A very simple way of laying out the shape of teeth is shown by Fig. 68. If this doesn't give the best possible shape to the teeth, it has the advantage of always having the centre fall within the points of teeth, and is easily worked off with less liability to error. Now, I consider the spacing of the teeth of the first importance. When this is destroyed by trying to follow some shape made up of more than two simple curves, and consequently difficult to lay out and work accurately, it is sacrificing practice to theory. This applies to spur wheels also. It is also essential that the face of teeth on spur wheels should touch all the way across the face. This is usually accomplished by making the draft on each wheel of a pair equal, and then in fitting them up, one is reversed. This is usually arranged by the designer or draughtsman. To make the teeth of bevel touch across the face they must be so worked that a line drawn from any point on the outline of tooth at the greatest diameter to the centre should touch the tooth across the whole face. By means of the instrument shown in Fig. 69, this may be done very accurately.

In this tool, the rod *s* should be perpendicular to base *k*. The collar *l* is made to slide on *s*, and is clamped by screw *m*; there is another collar *n*, which is always free to revolve on *s*. This has a pin on each side, one of which is shown at *o*. These pins should be central and at right angles with *s*. This forms a joint, allowing the straight-edge *p* to move up and down over the face of tooth. The trial side of straight-edge should lie in a line which runs to the centre of rod *s* and also to centre of pin *o*. In use, the instrument should be made fast to the spider of wheels by screws through the base *k*. Of course the spider should be true with the rim; then locate the pin *o* by the line across its

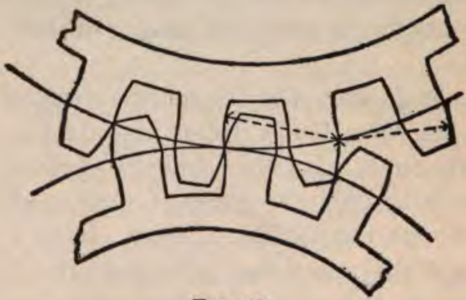


FIG. 68.

centre at a distance equal to the radius of opposite wheel above the pitch line, and fasten the collar *l*. The rod *s* should of course be in the centre of wheel and may be so

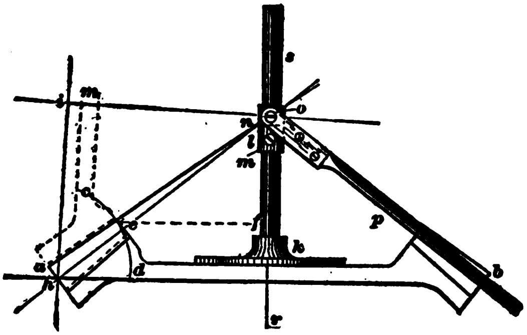


FIG. 69.

placed by the circular base. Then the straight-edge is free to move all around the wheel, and if you work off the teeth so that it will touch the whole surface you will have a pretty good wheel.

CHAPTER VII.

PROPELLER WHEELS.

I DON'T propose to go into any scientific discussion of the merits of different-shaped blades, straight or increase pitch, or any of the other points, good or bad, real or fancied. I am going to try and tell how to construct a pattern for a given pitch and diameter. As the same general directions will apply to all wheels, let us first consider a plain straight pitch—say, a wheel 8′ diameter and 12′ pitch. By 12′ pitch I mean that the wheel would advance 12′ during one complete revolution if there was no slip. Imagine, if you can, a bolt 8′ in diameter having a thread of so steep a pitch that it makes but one turn in 12′. Cut a segment out of this thread and you have the blade as stated. This bolt, if turned in an iron nut, would advance 12′ in one revolution, but in the water there is always more or less slip, as it is called, or lost motion, owing to the yielding of the water, which is the nut for the wheel.

We shall want a drawing first, showing the pitch, shape of hub, and thickness of blade at different points, although the thickness can only be located positively at all points when the outline of blade is known. Some designers wait until the face of wheel is worked off before laying out the shape of blade; so it is customary to allow plenty of stuff on the back side, that the thickness of bucket may be so located, after the outline is given, as to give the best backing qualities consistent with strength.

Let the curved lines *a b*, Fig. 70, represent the full size and shape of hub desired, and the parallel horizontal lines *c d* show the courses of pattern; then draw lines showing the pitch at different points. The line *e f* gives the pitch at extreme length of blades, *g h* at the point where the fillet between blade and hub begins. You may draw as many more between these two points as you think necessary or as the shape of the blades requires. This is not necessary for a straight pitch, as it can be taken from any point.

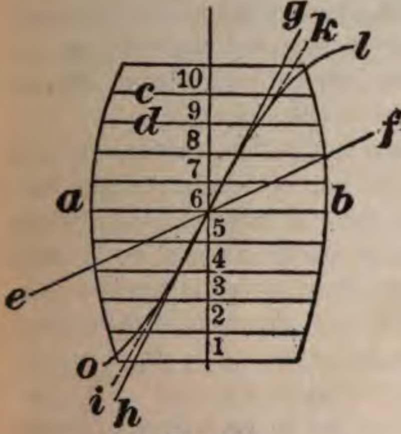


FIG. 70.

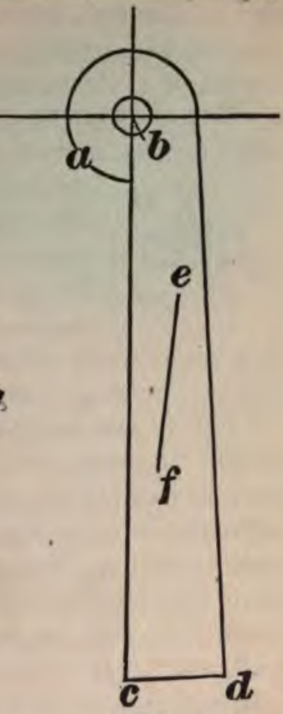


FIG. 71.

Now get a piece of stuff for a templet and dress to a parallel thickness equal to the thickness of courses in pattern. Having determined the centre point (*b*, Fig. 71), draw a circle, *a*, smaller than the hub, yet large enough to give sufficient strength around the hole for a spindle, shown by the small circle, *b*, used in moulding. Draw a radial line, *b c;* this is the face of wheel. Measure off on this line four feet from centre, *b*, and cut off the end of templet to this length. Now set a bevel on the pitch at circumference of wheel, as shown by line *e f*, Fig. 70, and lay this off on end of templet, as at *a b*, Fig. 72. Then measure thickness required at this point, as *c*, and draw another line parallel with *a b*. This last line determines the width of stuff necessary at this point, as *c d*, Fig. 71. By the same operation we may find the width at any point and thereby get the shape of back edge of templet, adding as much as you like to chop off again.

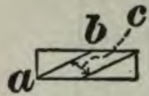


FIG. 72.

You may now cut up the stuff for one bucket, which is all that is usually made, as the moulder makes the two, three, or four buckets, as the case may be, from this one pattern by swinging it on its spindle and making as many flasks as wanted. You can count up the courses necessary on the drawing, and it is a good plan to have them numbered. The stuff can be cut pretty nearly the shape desired, which is the shape of templet, Fig. 71.

In cutting up the stuff, see that the grain runs *out toward* the face and point, as you will chop off the wheel from the hub toward the point, so the grain should run in the same direction as line *e f* on templet.

We will now lay out the first course, having dressed the stuff to a parallel thickness and out of wind. Get it out the same thickness as in drawing, Fig. 70. If the stuff is thicker than shown on this drawing, and is laid out by the templet, it will be too narrow; and for the same reason, if the stuff is dressed too thin, it will be too wide.

Turn the piece for course, bottom side up; then lay out a circle the full size of hub on line between courses one and two. From the centre of this circle draw a radial line *b c*, Fig. 73. This line is the face of bucket. For the back face lay on the templet, being sure to have the centre coincide with the centre of course.

A good way to accomplish this is to bore a hole $\frac{1}{8}''$ diameter through the centre of templet and also through the centre of each course, then use a piece of wire that will fit this hole to centre each course. Now bring the face of templet to the radial line *b c*, Fig. 73, and mark the width at circumference. The width at line *g h*, Fig. 73, will be seen at *c d*, Fig. 75. The pitch at this point is shown by line *g h*, and the general outline of back side of blade by curved line *g i h*. As the blade tapers in thickness from this point to circumference, the line of back should be curved from this point to end of blade like *e*, Fig. 73. Lay out the fillet between blade and hub as at *f* and *k*, draw a line *b m* from centre of hub to centre of fillet; draw another circle the same diameter as end of hub. Then cut this course to the full lines, Fig. 73; mark the pitch and thickness on end of course as shown on end of templet, Fig. 72.

The pitch at any point between *g h*, Fig. 73, and circumference may be found as follows: Let *g h*, Fig. 75, be the pitch at *g h*, Fig. 73, and *e f* the pitch at circumference, *j k* the centre line and g' *e* parallel with j' *k*; now divide the two lines *g e*, Fig. 75, and *g c*, Fig. 73, into an equal number of parts, a^1, a^2, a^3, a^4, and b^1, b^2, b^3, b^4. Now a line drawn from centre *p* to b^4 will show the pitch line at correspondi point on first course as at a^4.

The first course is now ready except boring the hole f spindle. Be careful and bore this hole square through t course and large enough to fit spindle. The point *l*, F 73, is located by the number of buckets; if for four, the d

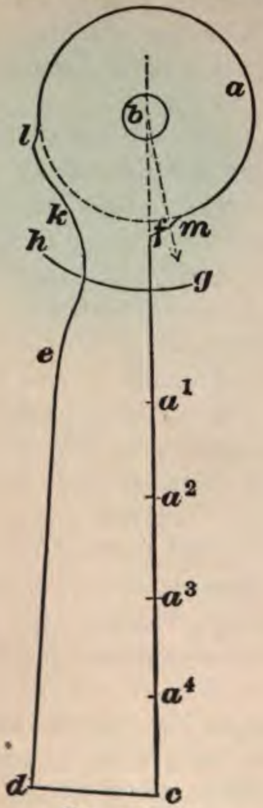


FIG. 73.

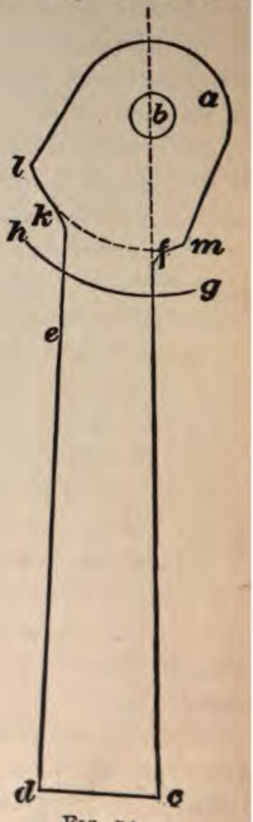


FIG. 74.

tance *l m* is a little less than one-fourth of the circumference.

Now we have on this first course lines showing the end of hub, the face of blade, the fillet connecting face of blade with hub, also the outline of hub on joint between one and two courses from *l* to *m*.

For the second course, having dressed the stuff, lay on templet and bore small hole through centre; mark along the face of templet and around the hub, also the width at circumference. Then remove the templet and draw a circle the size of hub on line between second and third courses; lay out the fillets and get the width on line *g h*, Fig. 74, as from *m* to *n*, Fig. 75. Now from the point *m*, Fig. 74, which marks the intersection of fillet and hub, lay off a distance equal to *m l*, Fig. 73; draw lines from *m* and *l*, Fig. 74, tangent to circle *a*, then you have the second

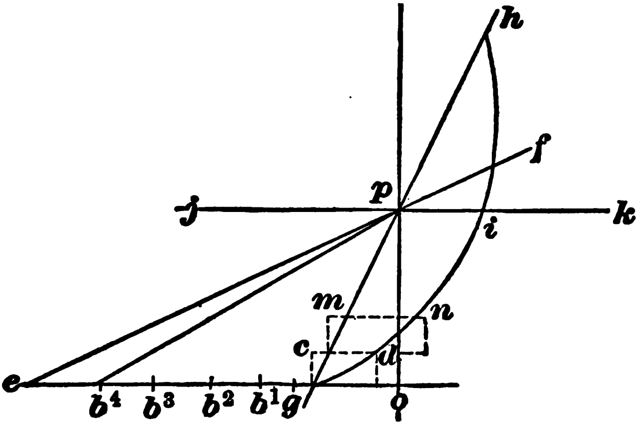


FIG. 75.

course, Fig. 74. Bore the hole for spindle and mark the pitch and thickness on end of course.

Turn up a hardwood plug or arbor to fit the hole bored for spindle, eight or ten inches long.

Lay the two courses now cut out together, pushing the plug through both, then moving them until the face of second course exactly coincides with the point where the pitch line on end of first course meets the top surface of course. Then glue them strongly together, using plenty of hand-screws.

While the first joint is drying we will lay out another course, getting the dimensions necessary from Fig. 70, always laying out the course on bottom side.

After the first joint has dried we will put on the third course the same way the second was done. It is a good plan to start by fastening the first course to a pair of trestles; this keeps your work up level and gives a good chance *for the* hand-screws. When it gets up too high, shift it to

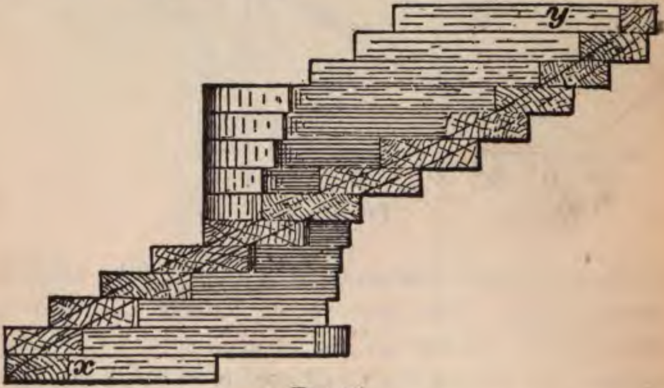


FIG. 76.

the floor, always putting on one course at a time, and remembering when we get above the centre to take the radius for line *l m*, the size of hub from line between courses 7 and 6 for seventh course, instead of on line between 7 and 8, as was the rule below the centre. It will be seen by Figs. 76 and 77 that it requires two short courses above what is necessary for the length of hub; Fig 77 shows the width of these courses so plainly that I don't think it is necessary to say anything further about them except that they are to be glued down on a radial line the position of which is governed by the width of courses at the end of blade.

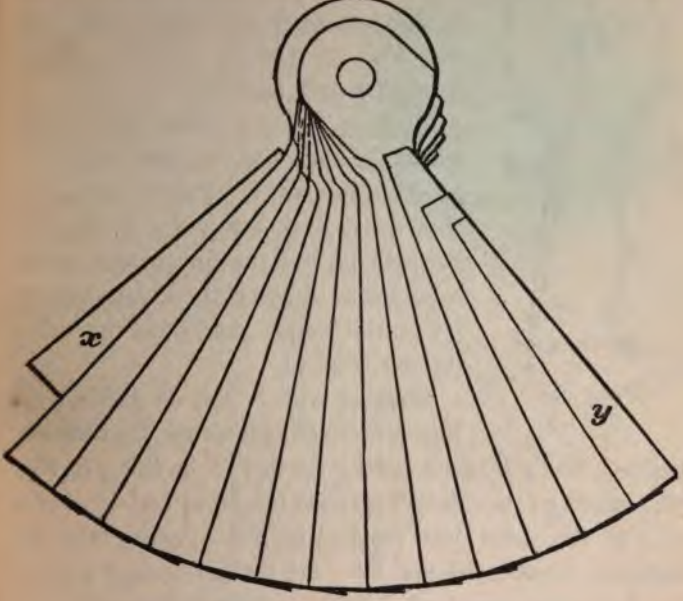


FIG. 77.

It is well to try the wheel three or four times when gluing up to see that the courses or joints are kept parallel with the first course laid down. If you allow them to run out of parallel lines your wheels will be crooked.

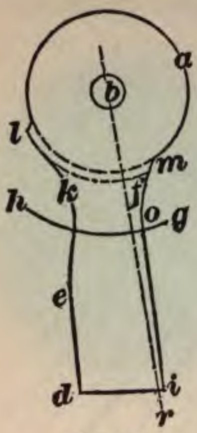


FIG. 78.

The job as it now stands will look like Figs. 76 and 77 with the courses marked *x* and *y* left off.

Now let us see what the result would be in case we had used the modification of a straight pitch, as shown by lines *i k* and *l o*, Fig. 70. We will lay out the first course, using these lines. Lay off the hub as before, lay on the templet, and draw the radial line *b r*, Fig. 78.

Measure with a pair of dividers on line, bottom of first course, the distance between line *g h* and line *i k*; set this off on line *g h*, Fig. 78, toward *g*; then draw a straight line from end of course at *r* to the point just marked on *g h*. Again, take the distance between *i k* and *l o*. Set this off toward *g* from the last point found of this line. Now you should have a templet the outline of which at face of bucket should start with a curve suitable for fillet and from this should run to a straight line, like Fig. 81. This is used to lay out that part of the course between the straight line at *i*, Fig. 78, and the fillet at *f*, and is placed so that it touches the straight line *i* and runs through the point *o*. This point is located by the distance of curved line *l o*, Fig. 70, from the straight pitch line *g h*, measured on the bottom line of the course you may be working. This will give us a first course like Fig. 78. From this shape the face of courses gradually approaches the true radial line until the centre of wheel or hub is reached. Here and here only the face of bucket lies in a radial line. After passing the centre the variation on line *g h*, Fig. 78, should be set off toward *h*.

On Fig. 80 the face of first course is shown by broken line *a* and the face of eleventh course by similar line *b*. This you will see widens the section at *g h*, Fig. 78. The shape produced also offers less resistance and is calculated to increase the backing qualities.

Now get out your adze and chop off the face of wheel. If you are as poor a hand with an adze as I am, you will

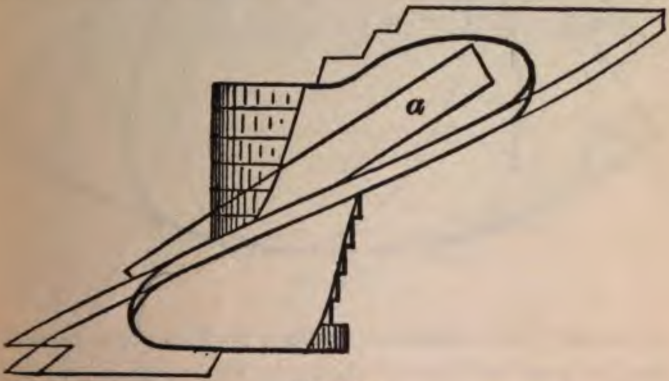


FIG. 79.

need to be very careful or you will get below the surface as shown by lines on Fig. 76. Then finish up with plane and spokeshave, being careful to work just down to the lines formed by face of courses, and don't leave the face all humps and hollows, because it won't look nice, to say the least.

After shaping the wheel to the desired outline, which may require the addition of more courses at top or bottom,

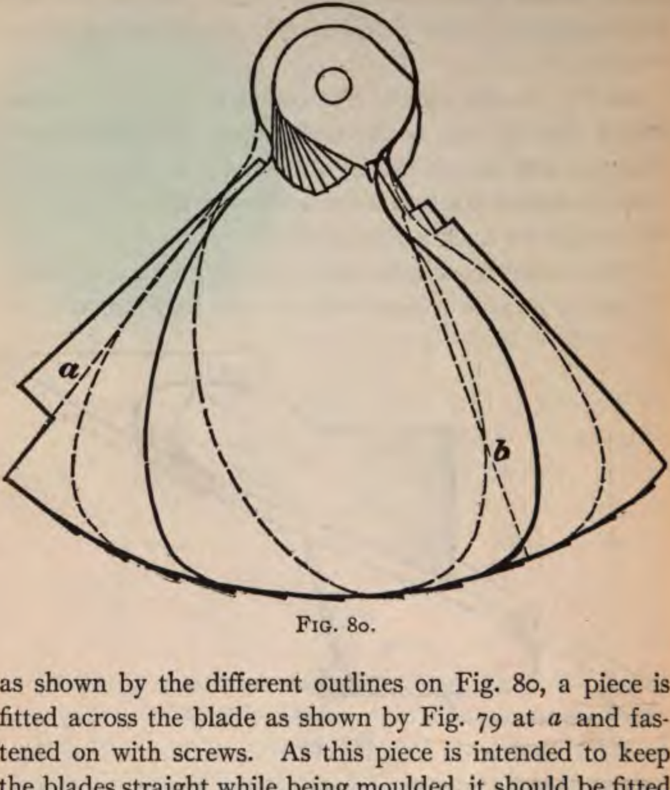


FIG. 80.

as shown by the different outlines on Fig. 80, a piece is fitted across the blade as shown by Fig. 79 at *a* and fastened on with screws. As this piece is intended to keep the blades straight while being moulded, it should be fitted very closely and well fastened.

Now turn over and chop off the back to the right shape, after which the pattern will look like Fig. 79. Then, if you will "sharpen" the edge all around, your pattern is ready for sandpaper and varnish.

For an increase pitch but little further explanation is required. In the drawing, or drawings, for it is better to make as many drawings as you have sections, on each drawing place a line indicating some definite straight pitch —the same pitch for all sections and all crossing the same centre. This pitch line, together with the radial line made by templet, Fig. 71, is the starting-point from which each course is laid out.

Your drawings will have the general appearance of Fig. 82, in which *r p s* represents the increase pitch line and *e p f* the straight pitch.

All courses must be laid out from a radial line and this radial line must always pass through some point on line *e f*. This point must also be the point where the line *e f* crosses the surface of the course you are laying out; then by measuring on the bottom line of course from *e f* to *r p s* the desired pitch may be laid out. It will be found necessary to change the bevel of line showing pitch at circum-

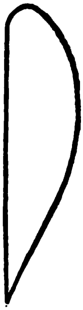


Fig. 81.

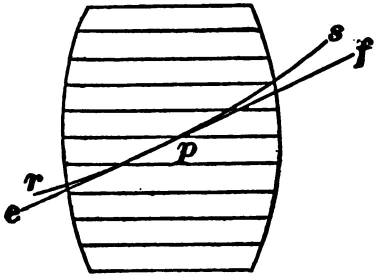


Fig. 82.

So we will have to make this thread with cores. We first turn up a straight, round piece to the largest diameter of drum, and part it through the centre as is customary with nearly all patterns. Make a line around one end, while in the lathe, to lay off the spiral from, and be careful to place the centres exactly in the joint or parting in order that the two halves of pattern may be alike. Then by spacing from the line of joint you may draw lines parallel with the axis of drum, dividing the surface into four, six, or eight different parts, according to the size of the cylinder and the pitch of the groove. If the pitch is coarse or steep make more parts, and the larger the cylinder the more parts you should divide the surface into.

Divide the pitch into the same number of parts as you have made on the circumference of cylinder; lay off one part of the pitch on the first line, two parts on the second line, and so on, around the cylinder, counting the joint on each side as a line until on the last line you lay off the full pitch. Now with the dividers set to the pitch, and starting from these points, which, by the way, are to be laid off from the line made around pattern in the lathe, you space off each line the whole length of drum. In laying off the first turn of spiral you should make it right- or left-handed, as may be wanted.

Now you need a templet to draw the lines between these points already found and which are intended to locate the line of spiral. Make your templet in this way: Fit a piece of hard wood to the surface of the pattern five or six inches long and one-half inch wider than the spaces between parallel lines. Straighten off one edge to one of the lines; make a gauge line on the side next cylinder at a distance from the straight edge equal to one of the spaces between parallel lines on cylinder. Square across one end of the piece for templet. Then measure on the gauge line from the squared line a distance equal to one of the parts into which the pitch was divided. A spiral line drawn from this point to the point where the squared line intersects the edge of templet will show where to cut templet.

This spiral line may be drawn in the manner illustrated on page 261, Pattern Shop Mathematics.

With this templet you may lay off the line of thread or groove the whole length or drum.

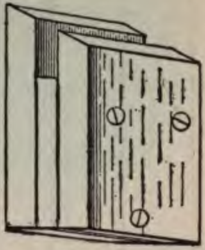


FIG. 84.

For the core print, which needn't be over $\frac{1}{4}''$ thick, get out some pieces like staves of the same thickness of print and about two inches wide. Make a box to cut them into lengths, sawing them on a line as near the pitch as you can. Fit each piece to the line of groove on cylinder and gauge them to the correct width, or you may make a box that will cut them to the width and bevel them so that they will draw out of the sand all at one operation. Make it of hard wood, like Fig. 84.

Make the space left for the prints so that one of the pieces will slip in easily, then put it in your bench vise; this holds all firm to work off print. You must be sure to give print bevel enough to draw. Test this by holding a piece on the drum and trying it with your square.

After you have fastened all the prints on, the next thing in order is the core-box. This should be made as long as will be convenient to handle and still be an equal part of one half the pattern. The box will have a section Fig. 86, and is made of four pieces and parted on perpendicular to axis of pattern. Get out the pieces enough, in the direction of l of pattern, to cut off to the after they are squared up.

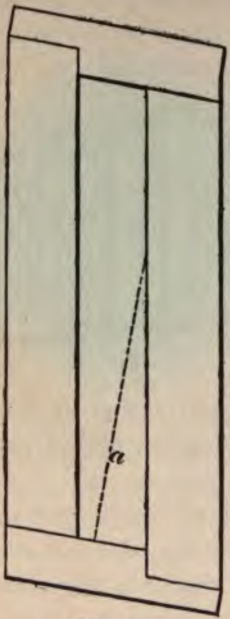


FIG. 85.

If the groove is to be sto square off before reaching th of pattern, it will only be nece to stop off the core to length ne as shown by Figs. 87 and 88; the groove or thread is run o the end like the thread on a you will have to make one or haps two pieces to lay in b shown by dotted line *a*, in Fi to make the core fit the end o tern. This piece is also shown in Fig. 86. The great difficul making patterns having a thre spiral groove is in laying them you must divide the circumfe of patterns accurately, and als pitch, both into the same number of parts, and you must also be very particular in laying off the parts of pitch which locate the first turn of spiral on the surface of pattern.

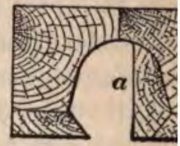


FIG. 86.

The spiral on this drum we have made need not be perfectly true, still it will look better if you make it as accurate as possible; and i exercise due care in laying it out you will be better pleased with the result.

For a spiral or worm, like Fig. 89, which is known as a conveyor, you will have to be very particular or you will make a failure of it. Turn up the pattern as a straight piece, one-half or three-quarters of an inch larger all over than the outside of worm. The pattern should have a length which may be evenly divided by the pitch, with the addition of the thickness of one thread. The ends should be draughted to match the taper of thread, and the ends of core-box made to match.

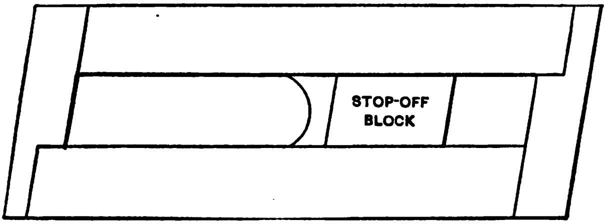


FIG. 87.

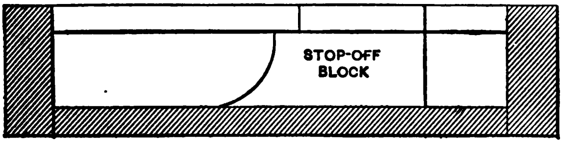


FIG. 88.

One end of the conveyor as shown has a projecting stud, and the other a socket into which the stud would fit. On each end of the pattern a piece of the size of hub at socket end and as long as the stud at opposite end should be turned. These form prints for the cores which form the pin and socket. The ends of the thread are cut off square, that the next section at each end may be fitted to form a continuous screw.

If you wish to use each length separate, making the length such as you want, you can fasten a piece of shafting in socket end, or the pin at the opposite end may be long enough to reach through bearing and into the socket on next piece.

You won't need to lay out the spiral on pattern, as the core-box does away with all that. Make the box a full half-circle of the length from *a* to *b*, Fig. 89. First make the ends; these may be turned to the taper of screw, then put on the outside in staves, as you would for a plain, round core the full diameter of pattern. Now put two half-circles on a face-plate and turn off to the same diameter as pattern; bore through the centre for the piece which is to form the central shaft or core of conveyor. The thickness of these pieces will be regulated by the length of

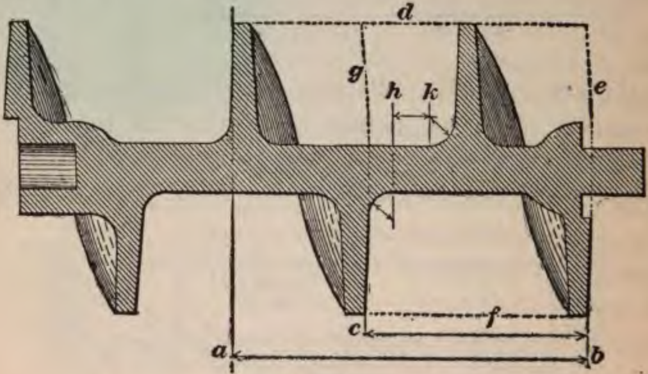


FIG. 89.

core-box; one side should be turned off like one side of a section of the thread. Lay off on the joint on each half one-half the pitch from the face side and carry the outline of thread back to this point.

Divide the circumference of these pieces as you did the circumference of drum for winding chain and get a line representing the correct line of thread. You must work this off by hand, and you can do it very nicely by turning a piece to fit the hole bored through centre; cut through the centre of this piece from one end and fasten to your template. By turning around and at the same time sliding up or down, the template may be made to reach every part of the face of loose piece, and will show you just where it wants cutting.

As this piece is larger than worm, you must make allowance for this on your template, carry the surface of spiral face right out to the full diameter of piece. After you have trued up the surface to fit template, gauge from the outside the extra thickness which we added to the diameter of pattern and cut it down to the thickness of thread at circumference. Now finish up the other half. This other half must now have the thickness of thread cut back at circumference, and fix them in the core-box at a distance apart equal to the pitch. If you have kept all your sizes right they will fix themselves. That is, if one piece is placed against each end of the box the distance between them will be right without any further fixing.

Then the space between them will be like the space between two adjacent threads on the worm, with the addition at circumference of one-half or three-quarters of an inch, which we added to the size of pattern, and which thickness reaches across the top of thread and serves to keep the cores at the right distance apart in the mould. The loose pieces should have a feather or dovetail let into the ends of box to prevent them from turning around and destroying the core when drawing off the box.

Now fit in the piece which is to form the central shaft of worm. This piece I should turn down to the size of shaft from *h* to *k*, leaving the ends of a size to fit the hole bored through loose pieces. This hole should be large enough to take in the full size of fillet between thread and shaft. This will make it easy to work off the face of spiral on the loose pieces, and you will also get in the fillet in good shape. This piece for the shaft must be left loose and taken out before the core is drawn.

We must now make provision for the ends of worm. The thread at each end must be cut off square, perpendicular to the axis, and also be cut so that one end may be an exact counterpart of the other, then any number of sections may be fastened together to form a continuous screw, by means of the stud and socket already mentioned. The most convenient place to stop off thread will be at the joint or top of core-box. For the box you should have, besides the loose pieces already made, a piece fitted to the ends of box and reaching from *b* to *c*. You must also have loose pieces to form the extra size of the shaft at the socket end and also at the shoulder on opposite end.

Now, to finish the cores for the ends of spiral, you take out one of the loose pieces and make a core reaching from the opposite spiral face to the end of box, as shown by the broken lines *d e f*; then put in the parallel thickness piece at this end of box, and you make another core reaching from the spiral face to broken line *g*. These two cores will form one end of the worm. Go through the same operation at the opposite end of core-box. Don't forget on these end-sections to make allowance for the extra size of shafts at each end.

If you have been accurate in the length of pattern and core-box, the cores will come out even with the length of pattern. You must also have a core-box of the diameter of end prints and long enough to make the core necessary for each end, with the addition of such length as will keep the two plugs, which I should use, in position, one for making the hole in core to form the pin, the other making the opposite end. These cores also form the recess shown at each end in Fig. 89, reaching to the centre of thread.

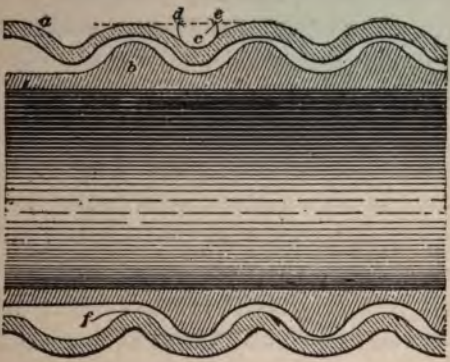


FIG. 90.

In Figs. 90 and 91 we have two forms of thread which may be moulded without cores. Fig. 90 shows a long nut *a* into which the screw *b* fits. The thread in the nut is made by a core-box, which is of the same length as nut, and has the thread cut on the inside. The thread on *b* is worked on the pattern.

Let us first turn up the pattern for nut straight and of the largest diameter of thread on the outside. This thread is formed only to keep the thickness of the casting uniform, and also to make it weigh less. You must be particular to keep the size uniform for the whole length of thread. Now, to lay out the thread on outside of pattern. If it is not over 4″ in diameter, I should take a piece of hard cardboard, and, having straightened one edge, put this to one of the joints in pattern, then roll the cardboard lightly on the surface; when you get around pattern, mark the paper where it meets the edge first laid on. Take off the cardboard and make a pencil line across one side at right angles with the straight edge. Make another line parallel with straight edge, at a distance therefrom equal to circumference of pattern, as has already been located by the mark we made when the cardboard was rolled on pattern.

On this parallel line set off the pitch measured from the line at right angles with straight edge; draw a straight line through this point and through the right angle formed by the straight edge and the pencil line; cut the board exactly on this line; draw another line parallel with this new edge, and distant therefrom once the pitch. Now, roll the pasteboard once more around the pattern, making the screw right- or left-hand as desired, and where the edge cut to pitch line crosses the straight edge see that it exactly coincides with the pencil line which is parallel to pitch line. The cardboard should overlap far enough to glue the two edges together, then we have a cylinder of pasteboard which fits the pattern, and will slide from one end to the other, and which has one end cut to the line of thread. With this templet we can easily lay out the thread on pattern. It is best to space off the pitch on joints, and then make the spiral, drawn by the help of the templet, pass through these points. This will check any tendency of the thread becoming uneven, as might be the case if we trusted to the templet alone.

After you have made one line, space off the distance shown at *d e*, Fig. 90, and then draw another line through these points parallel to the first line.

If your pattern is too large for a templet of this kind, you may space it off at the joint on each side, then make the templet to reach half-way around, or you may divide it up still more, as we did the pattern for chain-drum, using a templet, as we did for that pattern.

Now, if you will use a gouge which will fit the line *d c e*, you may work out the space between the parallel spiral lines and then it will be easy to round off the corners left at *d* and *e*. Make a block for sandpapering reaching across one space and a little beyond the centre line of thread on each side. You can put the pattern in the lathe and finish the sandpapering, running the lathe on a slow speed.

For the core-box we will get out the stuff in four or six sections, according to size of pattern, because we should have trouble in working a half-box. Joint the sections together, putting the two or three pieces which form each half of the box together by means of pieces screwed on across the joints. You must be careful to get the four or six parts of the box all equal, as we shall make the joints answer the same purpose as the parallel lines on surface of pattern for chain-drum.

You must first work your core box straight through, being careful to get it round and of the diameter of nut at point of thread at *f*, Fig. 90. Then make a templet, as we did for outside, reaching across one section of core-box, being particular about the pitch, making it just the same pitch as templet for outside. Divide the pitch into as many parts as you have divided core-box; and, after squaring off one end of the box, lay out the first turn of thread, as has already been explained, taking care that the thread shall start in the same place as on the outside of pattern. Then you may draw two parallel lines, regulating their distance apart by the intersection of the circle which bound the groove inside of nut, with the straight lines which mark the present surface of core-box.

In working this groove you will be well repaid for using extra care when you come to sandpaper, for if it is a small box I think you will find it the worst job of sandpapering you ever had.

Make the diameter of prints half-way between the largest and smallest diameter of thread; this makes the casting with the least fin possible at the ends.

For the inner screw, lay out and work in the same way that you made the thread on outside nut. The diameter of this screw will, of course, be governed by the clearance deemed necessary. The pitch, of course, will be the same as the pitch of core-box.

For a thread like that shown in Fig. 91, I think the quickest way is to put on the thread as we did the core print on chain-drum.

It may be worked in the same way, too, being careful to keep it up to size, and after it is all on put the pattern in the lathe, make a block to fit the space between two adjacent threads and reaching across the tops of thread, then by running the lathe at a slow speed you can finish up the job in good shape.

The nut shown is sometimes made in halves, and held together by means of a wrought-iron band, shrunk on, or it may be made by a core; in either case, I should make the thread in sections, and fasten on the surface of pattern or core-box.

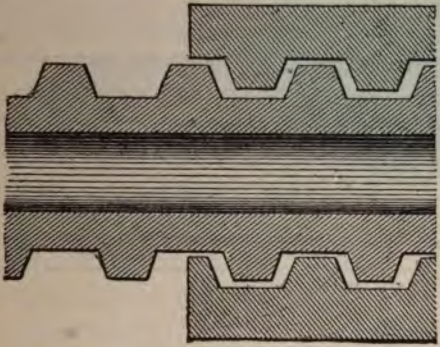


FIG. 91.

In all these core-boxes having a thread on their surface you must be particular to make a good match at the parting. This is best done by using good dowels and then putting the sections on either side of the joint together in your vise and finishing them with sandpaper while in this position.

Another thing you must be particular about in making screws and nuts which are to fit together is the pitch. It won't do to make the screw with a pitch of ten threads to the foot and the nut with nine and three-quarters or ten and one-half.

Fig. 92 shows a worm for use with a worm-wheel. This worm might be moulded in a horizontal position, but then the joint will always show on the casting. They are sometimes moulded perpendicularly, the moulder screwing the pattern out of the sand. When moulded in this way, the accuracy of the thread depends in a great measure upon the skill of the moulder. I think a great deal better job may be done in the way I shall describe.

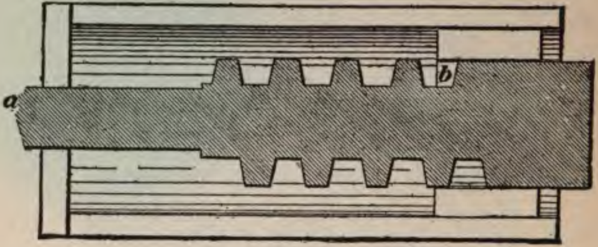


FIG. 92.

Make your pattern for worm with long ends, as shown in the figure, one end being of the largest diameter of worm. If you already have the pattern, you can fit a piece over the end to make it like figure. The opposite end should be of the size desired for spindle or shaft, or for core print, if the worm is to be cast hollow. If you wish to cast on shaft, make this small end of pattern the same size as shaft. This pattern is used in forming the core, which in turn forms the casting. The core-box is made round and large enough to leave plenty of sand outside of worm.

You will see by the figure that the thread of worm is worked about one turn more than is needed for the casting. The core-box is parted through the middle for convenience in removing the core when made. The end, marked *a*, is left open, with an arm across having a hole through it which the pattern will fit. The other end of box has a thick head, with a hole through it the same diameter as points of thread.

You will notice in the sketch that the thread of worm lies partly in this end of box. The pattern is placed in box with the right length of thread inside, and then where the thread enters head a piece is fitted, *b*, which will stop off the core, and is carried around far enough to completely fill the thread for a couple of inches.

After the core has been rammed up, which is done through the open end, the pattern is removed by screwing it out through the large end of box, the piece *b*, which we put in to stop off the thread, forming a guide for the thread and taking all strain off the sand. The small end of pattern must be long enough to reach through the box and support pattern after the worm has been entirely screwed out of the sand.

The advantage of drawing a screw in this manner lies in the fact that there is no joint in the mould and therefore we get a smooth, continuous thread without any chipping. This leaves the skin of the casting intact, which will, of course, make it wear longer.

If your casting is to have a hole through it, the core will stop off the mould at large end. If you wish to cast on shaft, make the small end of pattern the same size as shaft, then make an annular core. This core should be made in the same box that we made the worm in. The lower end of the core-box is fastened with screws; these may be taken out and the loose head moved up to make whatever length of core thought necessary to support the shaft. Use the worm pattern by placing it in the box with the end of worm even with inside of box, then ram up the core and draw the pattern through the large end of box.

If you want the spindle at both ends of cast iron, or of the same material as worm is made of, make a piece which will be of the shape you wish, making the two ends of the same size respectively as the ends of worm pattern, or possibly the same pattern may do if you want the two ends of the same diameter. In either case, put the form in same core-box that was used before and make whatever length of core you may want.

I think you will find your casting to be pretty good. One very necessary part, which I overlooked, is that you will need a straight, round pattern of the size of core-box, and long enough to make a mould that all the cores for the casting may be laid in. This mould may be poured on end or horizontally, as you may think best.

I have endeavored to impress, in these articles on screw threads, that accuracy is indispensable in laying them out.

Oftentimes a cast screw may be made to take the place of a cut screw, and where a great many are to be made will, of course, be much cheaper. If I have succeeded in showing how cast screws may be made, and made nicely, then I have accomplished my object in these papers.

CHAPTER IX.

TRACTION WHEELS FOR FARM ENGINES.

These wheels are sometimes to be made in such a way that the castings need no finish, even the hole for axle being left in the rough. Of course the casting must be pretty smooth and true in order to be complete as it leaves the foundry or cleaning-room. To get a smooth, true casting it is necessary first to have a good, accurate pattern, for I never saw a nice casting made from a poor pattern.

Let us construct a wheel like Fig. 93, which is a section of a wheel showing the arms. One of the treads or teeth to prevent slipping is shown at *m*. The figure shows the hub in detail. It is evident that the hub must be in two parts to admit of drawing one set or row of arms; then removing the sand between the two rows of arms, and finally removing the remaining part of hub with its arms.

It is also to be so put together that the core through hub will always come in the centre of wheel. No finish, you know. The hub must also stand true with the rim, so that the wheel must not *wobble.* In short, the pattern must be made about perfect, and this is the way I adopted to secure the desired end: The rim is to be laid up first and should be parted at the centre both inside and outside, for reasons given further on. Saw up the stuff for arms and let it be getting into some permanent form. Get the stuff for the hub out as follows: *a*, *b*, *d*, *e* to have the grain running from *f* to *g*; *c* to have the grain running from *h* to *k*, and long enough to reach through the whole hub as shown. Turn *c* with a pin on each end, then turn the other parts of hub to fit over pin and with the joints between *a b* and *d e* on the line of centre of arms.

The arms should be long enough to reach from outside of tongue *l* on rim to the hub and into it about 2″. Fasten *c* and *d* together, and then putting the other parts of hub together by means of the pins on *c*, lay out the holes for arms and work them nearly to the size; also lay out and cut the arms into rims, taking care to get every one in line at the point where they enter rim, and slanted up and down alternately.

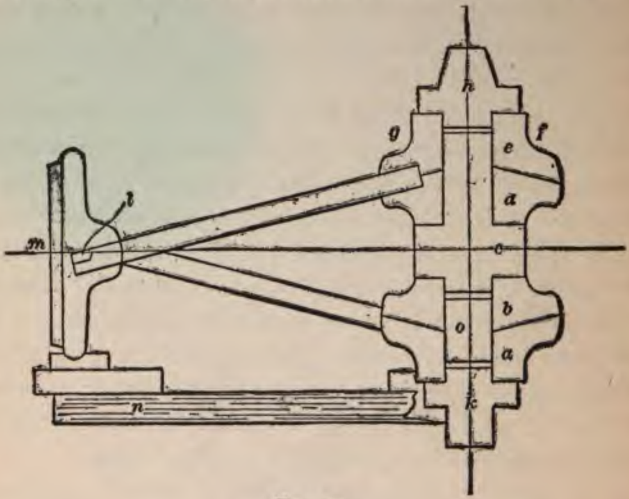


FIG. 93.

Now chuck the nowel side of rim on a large chuck; on the same chuck fasten part *a* of hub at the right distance from the centre joint of rim, all as shown by the portion of chuck *n* in figure.

Then fit in the first row of arms, letting one end just touch and clear in the rim; glue them into the part *a*, driving a small nail or screw through each one to retain it in position. Now fit down *b* and fasten it with glue and screws between the spokes; next put *c* and *d* in place, and fit in the other row of arms. Great care should be taken in fitting and fastening both sets of arms, as upon these depend the position of hub and core for axle. After fastening the arms and putting on *e*, the other half of rim may be fitted down.

Remove from chuck and test the centres by a pair of trams. If you have done your work accurately the centres on *c*, made by the lathe, will be exactly central with rim, and the arms will not spring in all directions so as to require a boy to hold each one in place while moulding. The pins on *c* should be cut off as shown in figure. Glue the piece *o* into *a* and *b*, then turn up the two ends of hubs *h* and *k*, which form a shoulder for the wrought-iron bands usually shrunk on, and also form the core prints as shown.

The projections on rim, shown in section at *m*, may be moulded on the wheel if their shape will permit it, or may be made in cores and rammed up in mould against rim. The best job is made by moulding on, then it will be found, if the rim is parted in the centre, it will make less work fitting these on, as both sides will be alike. This will be quite an advantage if they stand at an angle, as they often do.

CHAPTER X.

GLOBE-VALVE PATTERNS.

THESE patterns may be divided into three classes, as follows:

1. Iron valves above 6″ in size. Patterns and core-boxes both made of wood, the core-boxes made with loose seats. From 6″ up to 12″ it may be well enough to make whole core-boxes, to save changing seat, which wears out the boxes very fast. Above 12″ a half box so made as to change for the two halves of core, and also to change for making the angle, safety, and cross-valve of this same size, although a safety-valve of this size would be a rare thing. Still, the same change which makes the angle-valve would also make the safety or cross, so that, when we have so arranged the pattern and box that we can make an angle-valve, we can, by the addition of another branch on pattern, make either one of the others.

2. Iron or brass valves from 6″ down to 2″. Patterns for these may be made of wood, pine, or perhaps something more durable, if the number of castings to be made will warrant the extra expense. Core-boxes for these sizes may be made of iron, in two parts, from either wood or plaster of paris patterns.

3. Iron or brass valves from 2″ down. These, especially the brass valves, are usually made in such quantities that it becomes necessary to make the patterns of metal, gener-

ally of iron, and to have enough of each size and kind to fill a flask. They are all fastened together by gates, or are fastened in halves on a plate, and moulded on a machine.

I shall consider nothing but the body of a 16″ globe and angle combined.

The first requisite is a reliable working drawing. This *may* be furnished, but it is usually left to the patternmaker to make his own working drawing, and he generally makes a full-size, sectional view on a piece of board. To the credit of the craft be it said, that the patternmaker who can make a pattern from a scale drawing is also competent to make a working drawing of the same.

As we are going to construct a 16″ flanged valve (flanged valves only will be required of this size), we shall want a full-sized drawing like Fig. 94.

Now, it is not very likely that there will be many globe-valves of this size required, and as the pattern will be rather expensive, we had best make it in such a way that it will do for both globe- and angle-valves of this size, more especially as the same trimmings, with the single exception of the spindle, will do for both valves. Having arrived at this conclusion, let us see what modifications may be necessary to adapt the pattern to either form. The globe-valve receives steam, water, or gas at one end and discharges the same at the opposite end, the inlet and discharge pipes being in the same line. The angle-valve has the inlet directly under the spindle and the outlet at one side. Thus the line of pipe will form a right angle where it passes through the valve. In Fig. 95 I have given a sectional view of an angle-valve body to be made from the same pattern and core-box we shall make for the globe-valve shown in Fig. 94. By comparing the two, it will be seen that one of the branches must be movable in order that the three branches or ends necessary on each valve may be placed in the relative positions shown by the two Figs. 94 and 95. As it is customary to make the body in the form of a globe, the best way to construct the body will be to turn it up as a complete globe and then fit the branches to the surface. After the branches are once fitted to the surface of this globe, they may be fastened on in any position required.

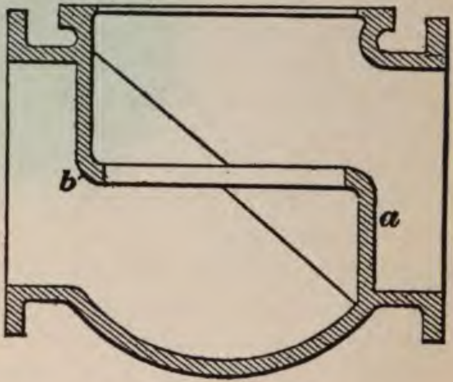


FIG. 94.

As a globe-valve of this size will require for the body a ball from 24″ to 28″ in diameter, it is evident that it would not be good policy to make the pattern solid, because it would be very heavy; therefore it will be best to lay this ball up in cants or segments. This will make the pattern light and strong.

By referring to Fig. 96 the manner of building up this *ball* will be plainly seen. We start with a round plate, as shown at *a;* screw a face-plate to one side of this, and face off in the lathe ready for the first course of cants marked *b* in the figure. Work the halves of the ball along together, and while waiting for the glue to dry get out four pieces for braces or arms, as long as the diameter of ball, and having a cross-section about 2″x4½″. These should be halved together at their centres, forming two crosses, one for each half of pattern. When you get the halves of the

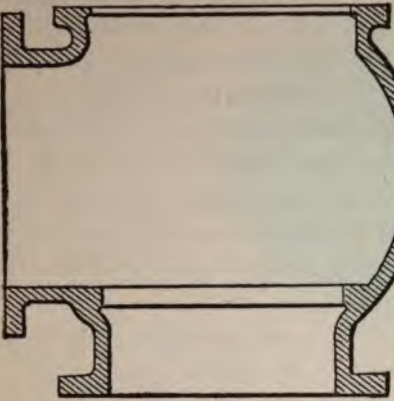


FIG. 95.

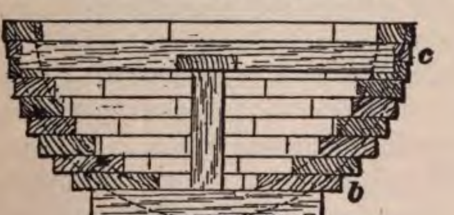


FIG. 96.

ball built up to the course marked *c*, rough out the inside to such size and shape as will leave it, when finished outside, about 1¾″ thick. Then cut in the braces, leaving some thickness of wood outside their ends. Put a couple of good screws into each end of each arm and also set up a support under the centre of the crosses.

Now put each half back in the lathe and face off for the next course, and also face up a spot at the centre large enough to receive a face-plate. Mark the centre exactly, then go on and finish gluing on the last courses; lay these aside to let the glue get thoroughly dry before turning them up.

In the meantime we will get the branches started. These will be best made up of courses. Begin with a solid head, which will form the end of core print. Get the gluing-up done and lay them aside to dry while turning the ball. For this you will need an accurate templet, and I would recommend making one as shown in Fig. 97, which will neither warp nor shrink out of shape. Change the face-plate to the opposite side on arms. Don't begin turning by facing off the joint and then bringing the surface of the ball down to match, but first bring the surface down to fit your templet, then turn off as much or as little as may be necessary at the joint. It is much easier to take off an eighth of an inch here than to turn it off the whole surface of the ball. Be careful to get the halves of the body exactly the same size, as it will make a good deal of trouble if one is larger than the other; they won't match, and the branches won't fit.

Cut the branches in halves and make the joint before turning. Here you must be very careful again to locate the joint exactly in the centre. You can't fasten them on the globe so that the parting will be flat unless both the body and branches are all parted on the centre line.

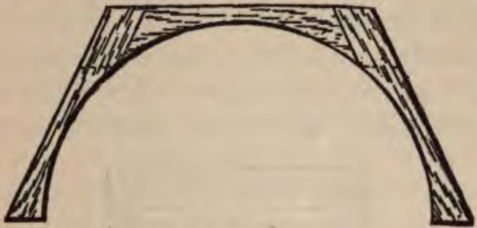


FIG. 97

The flanges at each end had better be made separate and put on with screws, so that they may be changed if necessary.

Now let us put our pattern together, as the turning is finished. Fit dowel-pins in the halves of globe to keep the pattern in place while moulding. Fasten a block on top of arms in drag-half of pattern, find the centre, and draw a line through this centre. This will fix the position of the inlet and outlet branches. Fasten on these two branches, being very particular to keep the centres of both body and branches all in the same straight line. We can

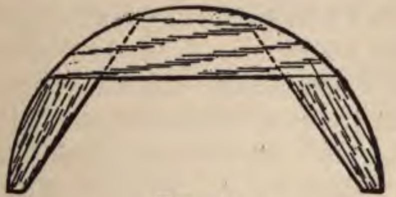


FIG. 98.

now locate the yoke end midway between these branches and at right angles with them. This is also a place where accuracy is very desirable if you wish the core to fit nicely, as the core is liable to be laid in the mould either side up, and it is evident that it won't reverse unless the yoke end of both pattern and core-box are central between the two side branches. Another reason: When it is central it is also at right angles with the centre line of branches; and, *vice versa*, when it is at right angles with this line it is also central. This follows from the mode of construction.

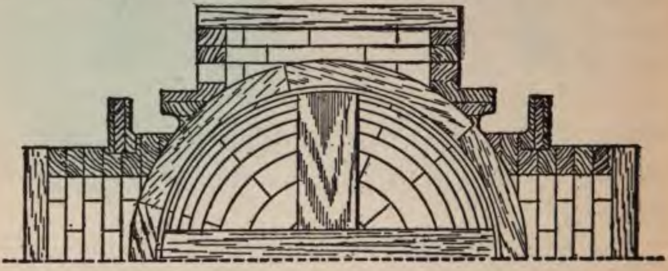


FIG. 9

Fig. 99 shows the pattern complete. Fasten on all the branches with plenty of screws and you will have a good, strong pattern and one that will mould nicely. Put a good, stout rapping-iron in each half of pattern for the amusement of the moulder. I once worked under a foreman who was wont to say, at times when the moulder had done something especially exasperating: "There never will be any moulders in heaven, because they are past all redemption." I don't believe this is literally true; still, it may be well to imagine so when putting in rapping-*irons,* and get in a few extra screws on that account, for the moulder is a trifle too willing to exercise his muscles.

And now let us take the core-maker into consideration and see if we can construct a core-box that he won't be obliged to entirely demolish in order to separate the core from the box. Perhaps the gentleman referred to above included the core-makers with the moulders in his harsh statement in regard to their final disposition. I presume he did, for he must have noticed, as we all have, that the average core-maker does love to linger around a big core-box and see in how many different places he can strike it with the heaviest sledge around the place. We must take all of this into account, and make our core-box strong enough to stand a good deal more banging than is necessary.

We must also provide some way of moving each side branch round opposite the yoke end in case we wish to make a core for an angle-valve. This will compel us to make three sides of the box just alike, the remaining side being the yoke end.

The best way to make this box is to build it up in segments, as we did the pattern; but, in order that it may not become a creature of circumstance and an eyesore, let us settle how we shall put the box together, then after this we shall be able to so build the body and branches that they may be easily fastened together and make a strong box after being so fastened together.

Perhaps the best way will be to construct it like Fig. 100. This gives us a square centre piece as large as can be made conveniently, then there is a good flange on each branch. By means of screws through these flanges we can fasten the branches on to the body part of box and make a good workmanlike job which will show the forethought and constructive ability of its maker. By the way, patternmakers are too apt to let a job "develop itself," and many a botch has been made in this way. A little forethought would generally prevent this, but the lack of it keeps many otherwise good mechanics down at the bottom of the ladder.

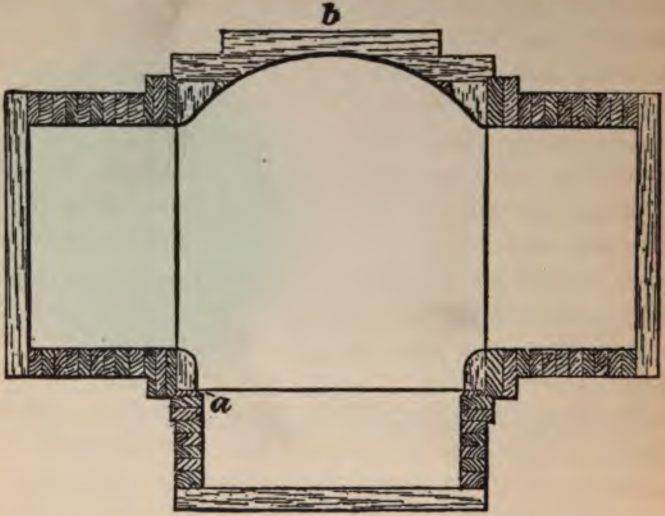


FIG. 100.

The first thing in order will be to find out how large we must build up the centre of box to make it finish to the size and shape shown by Fig. 100. This can be got at by laying out a full-size section of valve body, or you may put the necessary lines on the drawing you already have.

As the central part of box is approximately a sphere, it is evident that, if a slice is cut off the outside, the resulting face will be a circle or nearly so; then, if we know the size of the circle necessary to match flange on branch, and also the distance from the centre of globe at which the joints between body and branches must be formed, we shall then be able to lay out the diameter of outside of central part of box.

Let us fix on the diameter of flanges necessary. The inside of neck of valve is 16″ in diameter; add to this double the thickness of stuff necessary to form a good, substantial core-box, say about 2½″, then a flange about 1¼″ wide. This makes the flanges 23½″ in diameter. For convenience we will make the joints on all four sides of the box at the same distance from the centre. In fact, three of them would have to be alike anyway. We should locate the joints as far from the centre as one-half the diameter of flange found necessary, if possible; otherwise we don't get the full benefit of the flanges in putting on the branches.

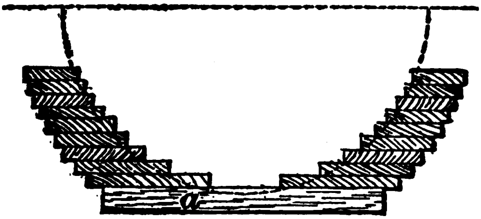


FIG. 101.

The actual distance of the joints from the centre will be governed by the point at which we shall find ourselves obliged to locate the joint on the yoke end of valve. This neck, as will be seen by referring to Fig. 94, has a narrow internal flange or shoulder. This is without any question the proper place for a joint. We shall need all the room this distance from the centre will give us; in fact, the radius of this point and the radius of the required flange will be seen to be nearly equal.

Make the joint just where the neck begins to narrow down to this flange. Draw a line through this point parallel with the centre line of branches, and lay off on this line, measuring each way from the centre of neck, the diameter of the flange. Now place one point of the trams at centre of globe and scribe a circle of such size that the circumference shall pass through the points marking the diameter of flange on branch of core-box. This circle will be the circumference of a sphere which, if cut by a plane at a distance from the centre equal to the radius of a circle to which the line marking the joint between body of core-box and the branches is tangent, the resulting face will be a circle of the same diameter as flanges on the branches of core-box.

Now that we have found the diameter of the sphere necessary for our purpose, let us begin to make it. First, we want a plate, round, and of the thickness and diameter shown by *a*, Fig. 101. On this foundation we will build up the segments as shown in Fig. 101, taking care to make good joints between courses, especially on the first courses, where we shall have very thin edges after the box is finished. Put on about six courses, then make a templet like that shown in Fig. 98. This one should be cut to fit inside the required circle, instead of outside, like the one shown in Fig. 97, but it should be made of three pieces, to keep the circle true.

Now, before putting on any more segments, let us turn out what we have already glued. You will see that it is easier to do this now than to wait until the whole box is laid up. Then build on again to within four or five courses of the top. Turn out the inside again, and while the box is still in the lathe mark the centre in the bottom of box, then put a piece of stuff across the top of box, cutting to such a length as will fit snugly in the box and hold the piece even with the top; on this piece mark the centre again. We are now ready to square up the outside of box. To do this, draw a line through the centre, lay off on this line, each way from the centre, the radius of flange we shall form on the branches, and draw lines through these points at right angles with the line passing through centre. These lines now mark two opposite sides of outside of core-box; lay off the other two sides at same distance from centre as the first. If it is found, from the design of valve body or for any other reason, that it is not practicable to cut the four sides of box all at the same distance from centre, we must change our plan and cut only three sides alike, and if this is not possible then we must contrive to put in extra pieces on the short sides, to make three sides alike—it isn't likely that you will have any trouble of this kind in making an ordinary globe-valve, and the four sides should form a perfect square, or, failing in this particular, the core-box won't be straight after it is all together.

After the centre is sliced off to these lines, we will glue onto the top, at the corners, some blocks, to make up the height of the four or five courses or segments left off, and which would have been almost entirely cut off again, as will be seen by noting the size of the piece actually necessary to complete each of the four corners. By doing this you also get these corners, which are necessarily rather weak, in the best possible form, considering their size and shape. If these corners had been laid right up to the top with segments, the chances are that you would have had some vertical joints in these top courses, which would have made bad work; by putting on the five courses all at once you make a single piece take the place of at least five, and probably more.

The next thing in order is to finish up the branches. As we are going to make only half a box, we shall have to turn up only one piece to make both pipe ends of box. For the hub or yoke end we will lay up only half the actual length of this branch, then saw the flange off of one half and glue the two halves together, end to end. Then cut off the bevel inside of shoulder at *a*, Fig. 100.

This provides for three sides of the box. Before filling up the remaining side, let us round off the corners inside of box where the branches enter the body of valve. In fastening the branches onto the centre of box, be sure and get the two sides and the centre all in a line, then the yoke end must be put on at right angles with the sides and central between them. Without these precautions the two halves of core won't match together. After finishing the corners where the side branches enter, shift one of them around opposite the yoke and finish this side like the two already finished. We should make these three sides, which are to form the pipe ends of valve, as near alike as possible so that the ends of core-box may interchange.

For the fourth side of box we will make a piece like that shown in section at *b*, Fig. 100. This has a flange of the same diameter as flanges on pipe ends of box, and must be fitted to go on three sides of box. We are now ready to put in the partition which, in a globe-valve, separates the inlet from the discharge.

Begin by laying up in segments a cylinder that will make the "wings," a section of which is shown at *a*, Fig. 94. The crescent-shaped piece, commonly called the "half-moon," should be put together in three pieces, like the templet shown in Figs. 97 and 103. It is best to make two of these pieces, one for each side. This will make a little less work for the moulder, and consequently (?) will make a better core. At any rate, the core-maker won't have so many corners to trim off, or forget to trim off.

The manner of laying out the "half" moons, and also the "wings," is fully described in the following chapter.

To this description it is necessary to add the manner of fitting them into the box, and also show how they may be held in their places while the cores are being made.

The half-moon must be fitted into place first. The centre of box was marked while in the lathe. We shall have to locate the centre of thickness of half-moon by measuring from the centre of yoke end on the line of circle marking the circumference of body of valve; to do this, put a piece of stuff from the end of print on yoke end across to the opposite side of box. On this we can first find the centre of ball, then mark the circle across the piece of stuff, then locate the centre of yoke end on this circle. Now we must also mark a point on the opposite side of box which will be in line with the centre line of yoke end. And as the centre of ball is also on this line we have found two points on the circle of body which are exactly opposite each other and also in line with the yoke end. We will now lay off from these two points the position of the ends of half-moons, marking the point which is the centre of their thickness. We now have four points fixed. From each of these points lay off half the thickness of half-moon each way, adding to the actual thickness enough to form a fillet on each side. Now take the templet used in forming the inside of box; make one side perfectly flat, that it may be used as a straight-edge to mark the lines around the inside surface of ball. As we have three points located in each one of these lines, we shall have no trouble in making them straight. Cut the space between these lines down about $\frac{1}{4}''$ below surface of box, thus forming two continuous grooves down across the surface, intersecting each other at the bottom centre of ball, and forming equal angles with a line drawn through the centres of two side branches. The depth of these grooves may be gauged by a router, if you will substitute a wooden plate fitted to the inner surface of core-box for the usual flat plate.

These grooves form pockets to receive the half-moons, and will hold them firmly in their places. The half-moons may be fastened on a face-plate and turned, fillets and all, to fit in the box. They should have plenty of draft on each side so that the core will come out clean. Now cut them out to receive the wings and fasten them in the box by a screw through each end.

The pieces for wings should first be cut into quarters and then fitted together on a face-plate so that the joints shall intersect at the centre and each piece contain an arc of 90°. Then, after they are turned, they will all be alike.

To fasten these pieces in the box so as to hold them firmly and still allow them to be drawn out of the core is the problem now presented. The upper edges are held strongly by means of a cross-bar of hard wood screwed firmly to the wing and then fastened to the box by a machine-screw at each end tapped into a metal plate, which in turn is let into the top of box and fastened securely by long screws. This way of fastening brings them always to the exact position, the screws acting as dowels, and holding them securely. The usual manner of fastening the lower corners is by means of a pin fast in the half-moon at the centre of box and projecting upward into the joint between each pair of wings. This will not, as a rule, give very satisfactory results, and I will try to explain a much better way of holding these points in place.

If you will look down into the core-box after the wings are in position, you will see that the round corner made on wings at *b*, Fig. 94, leaves a three-sided space between the top edge of half-moon and the wing pieces. There will be one of these spaces under each wing, and they will be on opposite sides of the half-moon with each pair of wings. These spaces afford what I consider the best possible way of fastening or holding the wings at their lower corners, and which I will try to explain.

Note how far this space extends each way from the centre, then remove the wings and cut from the top edge of half-moon, ¼″ in depth for a distance each way from the centre, a little greater than was the space left between wing and half-moon, cut both half-moons and then fit into each gap a piece that will bring the half-moons back to their original form; fasten these pieces by a small screw at each end. Now put the wings back in box, first fitting a dowel into one half and making a hole to match it in its mate; this will prevent them from shifting by each other and leaving a shoulder or "overshut" on the valve-seat. Screw the wings down into their places, then fit pieces of wood into the three-sided places already noticed and fasten them to the pieces let into the upper edge of the half-moons.

Take out the wings and the half-moons and dress off the pieces just fitted to the surface of the half-moon on each side, then remove the little screws, and we have a piece the shape of which would be rather difficult to describe. This is to be sandpapered and varnished and used at a pattern to get castings from which, when fastened to the half-moons, will hold the lower corner of wing pieces firmly in just the right place.

For the angle-valve we will, of course, leave out the half-moons and wing pieces and put in the seat shown in Fig. 95.

We have now constructed what I consider a very excellent pattern and core-box for making either a globe- or angle-valve of this size. It is a durable pattern, and one that will compare very favorably in cost with any pattern made for the same purpose.

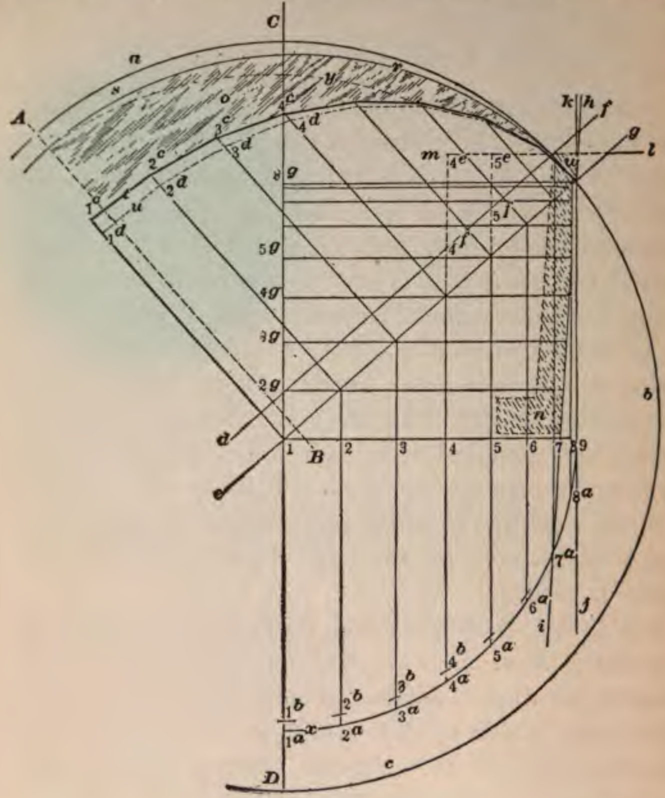
CHAPTER XI.

AN EXAMPLE IN PROJECTION.

There is probably no doubt but that the best way to cut the elliptical hole through the angular partition in a globe valve core-box is to chuck the piece to form the partition in the lathe and then bore the hole either straight or on a taper, as the design may call for. While this is entirely practical in the case of ordinary-sized valves with the help of a slide-rest lathe, it would not be so in the case of very large valves, or in a lathe not provided with a slide-rest. Therefore some other method becomes necessary. This has led me to put the method shown into practical form; for while there is nothing new in the principle involved, still there may be some who are bothered to apply this well-known principle to this problem, and for these few I have endeavored to make it plain.

Let the great circle, *a b c*, in the cut, be the line showing body size of core; the lines *d f* and *e g* showing the angular partition. The line *k j* is the outside diameter of loose seat, which in this case is to be straight. The angular partition is to be cut through parallel with centre line *C D*. The best way will be to make a templet for one-quarter of the hole, as follows:

From the point where the line *C D* is intersected by the line *e g*, which represents one side of partition, draw a line 1, 9 at right angles with *C D*, then draw the quarter-circle *x* 9 with a radius equal to outside diameter of loose seat. Now space off this quarter-circle into equal parts,



the more the better, and from each space draw lines parallel with *C D*, as 1, 2, 3, 4, 5, 6, 7, 8, carrying these *lines* up to line *e g*, and from the points of intersection draw other lines perpendicular to *e g*, as 1*c*, 2*c*, 3*c*, 4*c*, etc. Now with the dividers transfer the space between 1 and 1*a* to line from 1 to 1*c*, then the space between 2 and 2*a* to line drawn from *e g* to 2*c*; transfer the length of each line in turn, measuring from the line 1, 9, to quarter-circle *x*9, then transferring the space thus found to corresponding line drawn perpendicular to *e g* and measuring from *e g*. After transferring all the spaces, if we connect the points 1*c*, 2*c*, 3*c*, 4*c*, etc., we shall have a broken line, which will approximate the elliptic curve required, and if we would divide the quarter-circle *x*9 into an infinite number of parts, and then transfer these spaces thus formed to lines perpendicular to *e g*, we should get the curve perfect.

The departure from the perfect curve is not owing to any error in the principle involved, but is due to inaccuracy in the application. Still, this curve may be laid out by a close workman as nearly perfect as it is possible to work by hand in wood.

Now, make a template from line *e g* to 1*c*, 2*c*, 3*c*, etc., and draw the centre line *A B*. You can then mark off both sides of each half of partition, for you will want a right and left where the partition is bored parallel to *C D*. I think this is the best way to cut partitions, as it leaves the loose part in better shape. The shape of pieces forming the angular partitions is shown by shaded portion *o*. The other half of same side of partition would be bounded by the broken curved line *y*.

Now, if we wish to cut the partition parallel with line *A B*, so that the one piece may be used for making both halves of the core, mark the centre line *A B* on templet; then, by marking the same centre line across the piece for partition, and laying on the templet so that these centre lines will coincide, the hole through partition may be marked off, and the outside of partition will be cut on curved line $z\ r$.

In case the loose part of seat is to be tapered, as shown by section n, draw the line $h\ i$ corresponding with outside diameter of loose pieces; then draw other lines perpendicular to $C\ D$, and passing through the points where lines 1, 2, 3, 4, intersect $e\ g$, carrying them out to line $h\ i$. These lines are shown, as $2g$, $3g$, $4g$, etc.

Set the dividers from centre 1 on line 1, 9 to the point intersected by line $h\ i$; transfer this space to line $1D$, as from 1 to $1h$. Set the dividers again at $2g$, and take the space on this line between $C\ D$ and $h\ i$; move one leg of dividers to centre 1; then, with the other leg, mark across line 2, as at $2h$, making the distance between centre 1 and point $2h$, measured on a straight line, equal to distance on line $2g$ between $C\ D$ and line $h\ i$. Proceed in like manner until all of the spaces have been transferred from lines $2g$, $3g$, $4g$, etc., to imaginary lines between centre 1 and points $2h$, $3h$, $4h$, etc.

Now, setting the dividers again at centre 1, and measuring on line $C\ D$ to point $1b$, transfer this space to line from 1 to $1d$, perpendicular to line $e\ g$. Again, transfer the space between 2 and $2b$ from line $e\ g$ to $2d$. Transfer all the spaces between 2, 3, 4, 5 and $2b$, $3b$, $4b$, $5b$ to lines perpendicular to $e\ g$, as at $2d$, $3d$, $4d$, $5d$; then, by joining these new points, we get the curve, shown by line $1d$, $2d$, $3d$, etc., necessary to fit the tapered circular partition, shown in section $m\ n$.

We still have the loose pieces to cut off to line of angular partition. Make these pieces, when turned up, long enough to reach through angular partition, as shown by line *m l*. The circumference of these pieces will then be represented by quarter-circle x9. Then space off the edge *m l* of loose piece to agree with the spaces 1*a*, 2*a*, 3*a*, etc.; lay the piece on a surface-plate with side *m l* down, and with a right angle square lines up from these points and number them to correspond with numbers 1*a*, 2*a*, 3*a*, etc. Now carry the lines 1, 2, 3, 4 up to *m l*, as at 4*e*, 5*e*, etc.; then, by transferring the spaces on lines 1, 2, 3, 4 between lines *m l* and *d f*, as from 4*e* to 4*f* and 5*e* to 5*f*, to corresponding lines on outside of loose piece. The points thus found will all lie in the plane formed by one side of the angular partition, and shown in the figure by line *d f*.

To cut off the corner *w*, which projects beyond the circle *a b c*, lay the piece on a surface-plate with the side shown in figure down, having first marked the line of great circle across the edge. Then with a templet which has one straight side to lay on surface-plate, and the other sides bounded by a circle equal to *a b c* having its centre on straight side, we can make a line which will show just how much to cut off this corner by laying the templet against the already beveled side of loose piece, and drawing a line around the circular edge of templet passing through the point already located on the edge of loose piece by circle *a b c*.

There is still one more point to explain in case the angular partition is cut through parallel with *A B*, as it will then be necessary to cut off the corner of loose piece all the way around. After cutting the angular partition and also cutting the loose piece to line *d f*, place the piece on a surface plate in the position occupied when marked off corner *w*. Then by placing the templet used in laying out hole through angular partition against the beveled side of loose piece making the point at *w* coincide with the line of circle *a b c* on loose piece, draw a line around the curved side of templet. Now gauge off on the outside of loose piece the thickness of partition *o*. These two lines show just how much will have to be cut off from loose piece.

PART FOURTH.

METAL PATTERNS.

CHAPTER I.

COMMON PRACTICE.

METAL patterns for gating should be as light as possible, and may often be made hollow to produce this desirable result. For material from which to make the core-box to produce these hollow castings I know of nothing better than plaster of paris. Such boxes are cast over a core made of wood, and inside of a frame, or box of wood, which supports the plaster. The wooden core, or lightening core-stick, as it is called, is much easier to make than a wooden core-box, and the plaster box is all-sufficient for its purpose.

The mixture for brass patterns contains an overplus of tin, and should be all new metal; the large percentage of tin gives a good surface for the castings, which is more desirable than color for this work.

Sometimes white metal is used for patterns which are to be gated. All I have to say about this is—don't. White metal patterns are only to be tolerated where it is necessary to avoid shrinkage.

Aluminum castings are coming into use for gating and also for single patterns. Their extreme lightness is the only point in their favor, as they are difficult to treat, especially in soldering, and the shrinkage makes trouble. These objections, together with the fact that the foundry usually has to make a special pot of metal for them, almost prohibits their use.

Copper and tin, with a little spelter, make a metal that is easily finished, easily soldered, and has a harder surface than aluminum or any of the so-called white metals.

Gates may be of cast metal or of hard sheet-brass, the central or main gate being usually a casting. Sheet-metal runners are stronger and will cost more to make up. This extra cost is partly offset by their durability.

Iron castings are quite extensively used for single patterns of large size, and are more durable and cost less than those made of brass. Patterns for use on moulding-machines are usually made of cast-iron and are fine examples of the patternmaker's skill.

Wood patterns have also been used on moulding-machines with more or less success, although for anything which is to be produced in large quantities a metal pattern is the cheapest in the end. The moulding-machine manufacturers advertise that you can use your present patterns, whether of wood or metal, single or gated, on "our" machines, and you will find that it can be done; but when it becomes necessary to replace these wood patterns, you will probably make the new ones of iron. Brass does nicely for small pieces on machines. It is easier to work than cast-iron, but it will not stand the moulder's brush as well. Machine moulding does not allow the moulder to rap the patterns, so the patternmaker mustn't make his core prints fit too closely.

CHAPTER II.

SOME PATTERNS.

I AM somewhat puzzled to fix upon a good example for this article, which, being intended for the eyes of the profession, mustn't be too easy, and as I am hoping to instruct the boys, and also to interest those who have no need of further instruction (?), it must not be too hard for the boys or lacking in interest for the older heads.

I have in view a simple casting which is needed in small quantities for some lines of manufacturing, and can therefore be produced at a satisfactory price from a single pattern, but which in another shop is perhaps required in such quantities that the cost of patterns becomes of small importance when compared with the reduction made possible in cost of moulding and finishing.

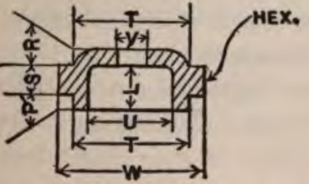


FIG. 102.

A good example of this kind of a casting is an ordinary waste-nut or gland-nut such as is used to hold the packing in the stuffing-box of the common brass globe-valve (see Fig. 102, which shows such a casting in vertical section).

If but few castings are wanted, a single pattern, perhaps a wooden pattern, might be considered as great an expense as was warranted, still with the single pattern we add to the cost of moulding, and also to the necessary weight of the casting by giving the pattern draft, and by adding weight, the finishing cost is increased, the finisher having to remove more metal.

The single pattern, when made of metal, may be a casting from a master pattern of wood. If not too large, a better pattern may be made from solid stock. Here, again, the demand for castings must govern the expense for patterns, keeping in mind the fact that the better the pattern the more uniform the castings, thus reducing the cost of finishing as well as foundry cost, while increasing the cost of patterns.

Unfortunately for the reputation of the trade, this happy result does not always follow the efforts which produce a large bill for pattern work.

While we have been trying to decide whether we will let the "cub" make this single pattern of wood, at a cost of perhaps ten cents, and then meekly submit to the tearful complaint of the moulder that he had to *dig* it out of the sand (surely the casting looks it), and calmly listen to the finisher, who, with considerable heat, explains that he has broken a special drill because there was so much stock to come out, and the casting was so rough that the chuck would not hold it, or whether to give the job to Mr. Sliderest, who would make it from solid stock at a cost of not less than a dollar, but in such shape that we shall never hear a word from the moulder or the finisher.

But the good spirits who guard and direct the efforts of the patternmaker now give us notice that they will require more castings than can be furnished from a single pattern, and it is decided to make a gate of patterns.

To produce these the master pattern is first made in wood, as accurately as possible, and with only a file finish if there are facilities for obtaining nice brass castings. If the nut casting required is small, better make the master pattern of brass, and then if there is doubt that the foundry will be able to furnish good enough castings (by "good enough" is meant such as can be finished with file and emery-cloth), then make all of them from solid stock.

The cost of patterns from solid stock can usually be much reduced by making one or two special tools for the lathe. As the work is revolved while the tool is held in either the slide-rest or the tail-spindle, a flat drill filed to the shape of the inside of the nut, but having only one cutting edge, using a pair of calipers to fix diameter and a forming-tool for the outside, will save much time which would otherwise be lost in making measurements and fitting templets. The hexagon portion of the pattern is turned to large diameter and then spaced in the lathe by the index which you have long before this marked off on the edge of cone-pulley rim, and a sharp line drawn to mark angles by a tool in the tool-post of slide-rest or by using a surface-gauge on any convenient part of lathe which is parallel with lathe spindle.

The filing of the flats is the most expensive part of the job, and really furnishes the strongest argument for the use of castings made from a master pattern; and castings *can* be made good enough for patterns.

If you decide to make white metal patterns for gating, change your mind before it is too late.

The gating of brass patterns is largely a question of usage, the runners being sometimes cast on the patterns; this interferes somewhat with the finishing of the patterns, but lessens the cost of gating. The runners may also be cast separately, mortised, and soldered into patterns, and then the pattern and runner soldered to the main gate. Again, the runners may be cut from sheet-brass, and the patterns mortised and soldered, one to each end of a runner, which is then placed cross-wise of the main gate, the main gate being cut down to allow the runner to go down flush, and then soldered, thus making one surface of the completed gate flat.

While this last construction costs more than the cast runners, the sheet-metal is stronger and the repairing is confined to re-soldering loose patterns. The cast gates often break at their weakest point, which is near the pattern, making it necessary to replace the whole runner or splice out the old stump with sheet-metal.

In finishing the runners, the material of which the casting is to be made must always be considered, as you will need a larger gate for composition than for either gray or malleable iron. Also for composition, there should be quite a large fillet left where runner enters pattern, while for iron there should be as little fillet as possible.

And now a word of caution about finishing the gate and runners. Always have in mind the fact that the gate forms a ditch (and really the gate as seen in some moulds looks like a ditch, and a very poor ditch, too) for the liquid metal, and the stream of hot metal will cut off and carry along with it any loose sand or sharp, weak corners left in the "ditch," depositing this drift in the castings and causing dismay among the stockholders.

Therefore, let the curves from runner to gate be easy, and as the runner approaches the pattern, make the draft clean and true so that the firm surface of the mould will not be disturbed by the moulder in drawing the patterns.

There is probably nothing new in all that has been said so far for the most of us, but when so many castings are required that we decide to use the moulding-machine, and the patternmaker is required to furnish suitable patterns, the task becomes more interesting, as I will try to show.

With the single pattern or with the gate of patterns the responsibility of the moulder is greater than with the machine patterns, while the reverse is true as regards the patternmaker, who is now expected to become machinist as well as patternmaker and furnish a set of patterns which shall have just enough stock for finishing, with no addition for draft or inaccurate work, also so arranged as to produce the greatest possible number of castings from a single flask of given size.

First, decide where the parting of mould is to be made. In the shape shown in Fig. 102 it must evidently be at one of the shoulders formed by the edges of the hexagon, preferably the upper edge, because the shoulder in core is nearly opposite this shoulder. While it is not absolutely necessary to make the parting on outside match the parting in core, it is better to do so if possible, as in this case.

There will now be required three master patterns, as follows: One like Fig. 103, which makes the lower half of pattern; one like Fig. 104, for the upper part; and one like Fig. 105, which is called the stool.

Before we can fix the dimensions, A, of Figs. 103, 104, and 105, we must consider the moulding-machine. Let us suppose that for Figs. 103 and 104, A will be 1½″; then A for Fig. 105 will be 1½″ plus thickness of pattern-plate; C, Fig. 107, plus space K, between screw H and plate C, which space is a little more than the greatest lift, in this case a little more than space L; plus the height of screw H, plus S, plus P, minus L. Seems rather mixed, doesn't it; but with something definite for the size of the casting, and knowing all the points of the moulding-machine to be used, it isn't very hard to fix this dimension, A, for Fig. 105.

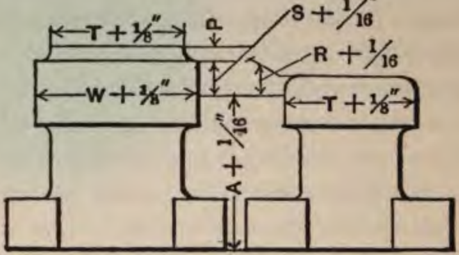


FIG. 103. FIG. 104.

The plan or bottom view of Figs. 103 and 104 is as shown in Fig. 106, the lugs NN, which are for the screws used to hold patterns in place on plate C, being so arranged that the patterns may be placed as closely together as possible and mould successfully. Fig. 105 is round in section for its whole length, and is not fastened to the plate X, its weight keeping it in place.

Masters, Figs. 103 and 104, must have finish allowed on diameters, S and W, all of which had best be made round, and also on each end. Fig. 105 must have finish on diameter U and also on ends. W must finish to largest diameter of hexagon—*i.e.*, across the corners, T to the round portion at top and bottom of Fig. 102, and U, Fig. 105, to the diameter of hole in bottom part of Fig. 102. All Figs. are lettered to correspond each with the others.

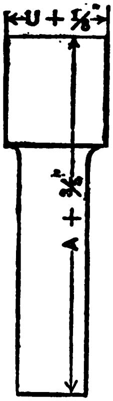


FIG. 105.

It is really the case that these patterns may be made and used successfully with absolutely no draft, the stripping-plate, B, and stools, U and V, Fig. 107, supporting the sand while the patterns are being drawn. It is impossible for the moulder to rap this form of patterns, and the castings come so true that it seems almost a pity to submit them to the skill (?) of the finisher. Some of the patternmakers who have perhaps not been favorably impressed with the appearance of finished goods may be willing to sympathize with me in this matter, as all of our craft know that neither the moulder nor the finisher ever fully realizes the poor patternmaker's expectations. Still they are necessary evils that the manufacturer must continue to submit to.

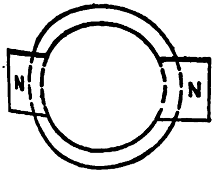


FIG. 106.

The castings from master patterns having been made, we proceed as follows: Fig. 103 is held in a 3-jaw chuck with its lower end out, the hole is drilled about 1-16 in. under size, then bored nearly to size and finished with a standard reamer to the required size, U, then mounted on an arbor, turned to size at T and S, the bottom end squared off true and flat, and the top end cut down within 1-32 in. of finished length. Now put a good, stiff face-plate on lathe spindle, see that the face is flat and runs perfectly true, drill a ¼-in. hole in centre of plate and bore it out to about ⅜-in.; the boring is to bring the hole central. In this hole fix a short piece of brass or soft steel, shouldered against plate, and large enough to finish to size U.

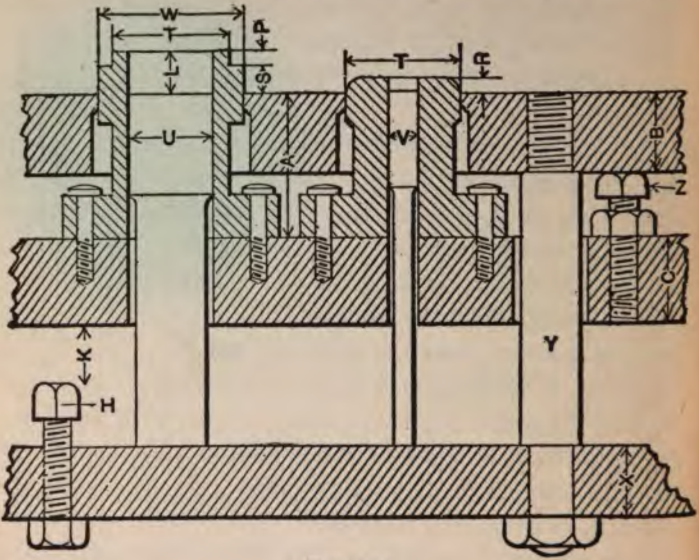


FIG. 107.

This stud may be secured by screw and washer from back side of face-plate, then finished to fit nicely in the reamed holes in parts made from Fig. 103. These parts are placed, one at a time, over the stud thus formed, the bottom end against the plate and secured by two L-shaped clips, placed with the long end on lugs shown on Figs. 104 and 103, and then bolted to face-plate.

The slide-rest is now set by trial until the tool cuts the first one to the exact length, after which all the rest may be cut to length without disturbing position of slide-rest.

As any variation in length of the patterns will be reproduced in the castings, it is well to be very careful in cutting to exact length, also when squaring bottom end it should be borne in mind that all of the patterns when fastened to plate C must stand up square and true or else the stripping-plate B will bind.

Now make a former tool to fit P in Fig. 102, leaving a small fillet in corner next hexagon, and by replacing the pieces, one at a time, on face-plate and getting the tool in position, first feeding in until the diameter is right, and setting stop on cross-slide, then feeding toward face-plate until the length is right, clamp the slide-rest and all of the pieces may be formed up alike by using the cross-feed only.

Parts made from Fig. 104 are made up in the same way, the hole being made like V, Fig. 102.

Fig. 4 piece is turned between centres and the small end squared off, as no centre must be left in large end of finished piece; this end is left long, provision for this being made by the $\frac{3}{8}$-in. added to finish length, A of Fig. 105. A spring chuck is made to fit diameter U, and nearly as deep as finished length A; the pieces are placed in this chuck, cut off nearly to length required, then replaced, and the tool set until it finishes the first one to the exact length, then without disturbing tool all are finished to same length.

There is a second set of stools similar to Fig. 105 required to fit hole V in part Fig. 104, but as these are small they may be made from machine-steel.

In making up parts Fig. 104, one extra is carried along through the different operations, until turned to size, then diameter W is cut down to small size of hexagon. This is used by the milling-machine operator to gauge the other pieces when the hexagons are milled to size.

As many of the posts, Y, and screws, Z, may be used as are thought necessary, but four screws, H, will be enough for any set of patterns.

The plates B and C are cast solid, and the holes for the patterns in B are spaced equidistant from a centre line, and at right angles thereto, by using a jig; the holes through C are drilled after the patterns are fastened in place.

When the machine is operated to draw the patterns, plate C is dropped with the patterns which are fastened to it, plate B, the stripping-plate, remains stationary, with the flask and stools V and U, these stools being supported by stool-plate X, which in turn is fastened to plate B by bolts Y. The motion of C continues until it strikes set-screws H, at which point the patterns are entirely clear of the mould and the cores are still supported by the stools Y and U.

A further movement of the machine may be made to raise flask from plate B, but as this is a critical moment, when a little unsteadiness in the lift may break some of the delicate cores, it has been found best, and especially so in the case of such small patterns as are illustrated, and which require only short flask pins, to trust to the skill of the moulder in lifting the flask. This skill may vary as pay-day comes nearer; in fact, it may be entirely wanting immediately *after* pay-day.

As the operation of the machine is evident, after the explanation given above and examination of Fig. 107, the only remaining point of interest to the patternmaker is the laying out and drilling of plate B. This is done almost entirely by the use of the jig mentioned.

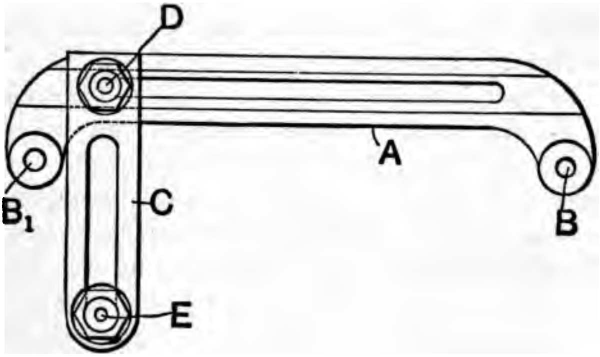


FIG. 108.

The jig spoken of in the former article is illustrated by Fig. 108, and it consists of a bar A, with the ends projected to one side as shown, to allow of drilling holes directly on centre line AA, Fig. 109, thus making it possible to cover the entire plate and allow for placing a pattern anywhere on its surface.

This bar has two guide pins, B and B_1, which enter holes drilled at each end of plate, exactly on the centre line AA. All spacing is done from these holes, thus making sure that all patterns are at uniform distances from the same central line. This is a very important feature in work of this kind, as every other mould must be reversed to form a cope for the preceding nowel.

The arm C is fitted to bar A with tongue and groove, which groove must be parallel with a line drawn through the centres of pins B and B,, and it may be clamped to A at any point by bolt through both parts at D. Arm C is slotted at right angles to A, for piece E, which consists of a hardened steel bushing held in place by clamping nut, and having a hole for a small drill. Finally the whole jig is so constructed that it may be used either side up.

And now a few words will show how it is used. Having spaced off the plate roughly to ascertain how many patterns can be used, and decided upon their arrangement as regards gating, we are ready to drill our plate.

Here is a good place to put in a few words about spacing. As I have given no dimensions to the castings for which these patterns are to be made, I can only approximate the spacing, and give a general rule for such work. Make the space between any two patterns in the same row not less than one-third of the height of the pattern, the distance between any two rows not less than one-half the height, and the distance from pattern to runner about one-half inch.

To return to our drilling. Fig. 109 is a plan of plate B, Fig. 107, each of the small circles representing a pattern. As the gates for each double row of patterns run lengthwise of the plate, and have an enlargement near one end where the sprue enters, this set of patterns must be arranged *so that* the alternate moulds may reverse by turning flask from front to back, rather than endwise. This means that pattern 1 must be at the same distance from centre lines AA and BB as pattern 1a. This is accomplished by setting bushing E, Fig. 108, to position for pattern 1, and then by reversing the jig the hole for 1a may be drilled without disturbing the adjustment of jig, and further, as pattern 2 is spaced at the same distance from line BB as pattern 1, but on the opposite side, the jig is now turned over end for end, and 2 is drilled; then again reversing the jig we drill 2a, thus drilling, or locating, four patterns with one setting of the jig.

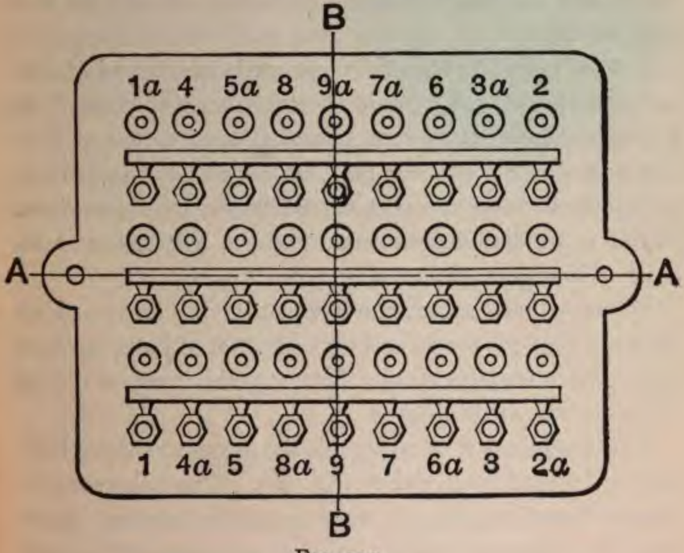


FIG. 109.

For the next hole, pattern 3, leave E, Fig. 108, clamped fast and loosen D, then slide arm C along bar A to position for 3 and clamp; this adjusts jig for the next four holes, 3, 3a, 4, and 4a, Fig. 109. It will be seen that the jig is made to follow the same motions that the half-moulds go through in using this set of patterns. By leaving E, Fig. 108, clamped fast until one entire row of patterns lengthwise of the flask, on each side of line AA, or line about which the half-moulds are revolved in making alternate copes and nowels, we locate each row of pattens in a straight line.

If it is desired to turn the copes endwise instead of sidewise, let D, Fig. 108, remain clamped fast and loosen E for each successive set of four patterns, until a row of holes has been made across the plate on each side of line BB.

The small holes are afterward enlarged by counterbores of size to fit diameter of round pattern, Fig. 104, and flat sides of hexagon pattern, Fig. 103.

We now make a hexagon templet having on one side a short projection turned to fit counter-bored hole, or diameter of flats on pattern like Fig. 103, this hub, of course, to be central with hexagon.

This templet is used to lay out the hexagon-shaped holes required for all patterns like Fig. 103. The holes are then counter-bored again, this time from the bottom side of plate, to a diameter slightly larger than corners of hexagon, and to a depth which will leave $\frac{1}{8}''$ thickness on top-surface to be filed through to lines marked around hexagon templet. In laying out hexagons, always have one flat side next the gate.

And now as to placing patterns. It will be understood that pattern 5a in nowel will become pattern 5 in cope, and as it takes one Fig. 103 piece and one Fig. 104 piece to make up a complete nut, there will be, in the completed flask, one each of Figs. 103 and 104 at 5, and also at 5a, and further, if at 5, on plate, we have elected to place one piece like Fig. 103, then there will be a Fig. 104 at 5a on the plate. Bearing this alternation of position in mind, the runners may be placed to connect only those patterns like Fig. 104, thus doing away with one-half of the runners and still having a runner to each casting.

The only difference between cope and nowel in using patterns of this kind is made by the moulder in cutting the sprues through the cope, three for this set, but by leaving out one or two pieces at the sprue end of each row, in all but two outside rows, the gates may be joined so that the moulder can pour the entire mould from one sprue instead of three.

CHAPTER III.

A STRIPPING-PLATE JOB.

THE casting to be made is shown, full size, in Fig. 110, and while it has since been demonstrated that it could be made on a simple vibrator plate, it was deemed advisable, as a great many would be used, to put it on a stripping-plate and save the metal which would be required to get the necessary draft for a vibrator-plate. Again, the castings from the stripping-plate, besides having less stock to cut off, would be perfectly straight, making it very easy to hold them for machining.

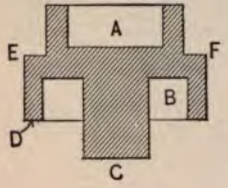


FIG. 110.

By looking at Fig. 110 it will be observed that there is a cavity in each end of casting. The figure shows a vertical section; all lines in a plan view would be circles. The cavity at A is comparatively simple, and can be managed in the same way as that shown in bottom of waste-nut, Chapter II., Fig. 102. The other end, B, of this casting, Fig. 110, is not so easily made, as it is necessary to provide a support for the central pin, C. This pin must be fastened to ring D in such a manner that it will move with D when drawing patterns, while the core which forms the cavity, B, remains fixed with the stripping-plate. This was accomplished as follows:

The piece, Fig. 110, was parted on line EF, which is also the top surface of stripping-plate, B, Fig. 111. The patterns for upper end, A, were made like Fig. 112, of hard brass, and the stool, like Fig. 113, of machine-steel. Pattern for lower end, B, was, like Figs. 114 and 115, also of brass. This last figure shows the piece which forms the pin C. The stool for recess B, Fig. 110, was made, like Fig. 116, of cast-iron; the lower part, up to line AB, being cast to finished size by the use of a core. The slot CD, being a little wider than the bar, A, of Fig, 115, the stool kept its relative position, while the stripping-plate A, Fig. 111, moved up in the operation of drawing the patterns.

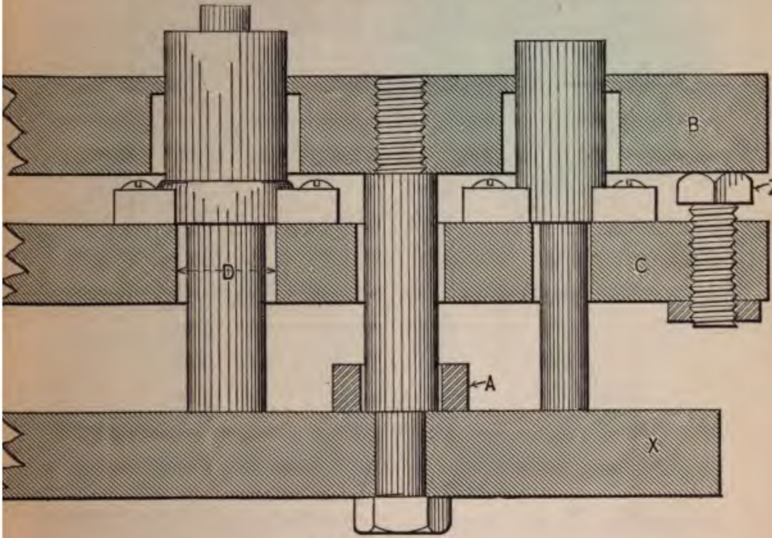


FIG. 111.

In all forms of stripping-plates, especially in those with stools, sand accumulates in the working parts and joints, and unless this accumulation can be easily removed considerable time is lost by the moulder. With the style of plates shown in Fig. 111 (and in Fig. 107, Chapter II.), when the machine is operated as for drawing the patterns, all of the stools are projected beyond the tops of patterns and may be readily taken out and cleaned, as they are not fastened in any way, their weight alone keeping them in place.

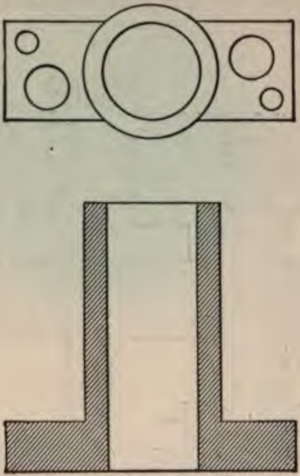


FIG. 112.

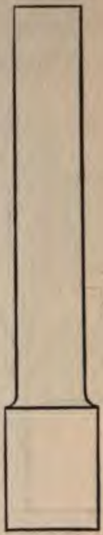


FIG. 113.

Pieces 112, 113, 114, are finished in the same manner as was described in detail for parts 103, 104, and 105, in Chapter II. Fig. 115 was turned between centres and then soldered into 108, being held in position for soldering by a sleeve which fitted pin C and hole A, Fig. 114.

The stool, Fig. 116, was the most difficult piece to make, as can be seen, the size and shape of the casting making it hard to machine.

First, the round hole which was cored in the lower end was reamed out, roughly, the free ends of casting being held in a ring, which was slightly tapered inside, and was forced out over the end. A bushing was then made to fit this reamed hole. As these holes were not all of exactly the same size, the bushing had to be fitted to the largest and forced into the smaller ones; and during the operation of drilling the casting was held firmly to bushing by a clamp-ring placed over outside of casting. This bushing was first used as a jig to guide drill for hole through upper end of Fig. 116, and with the hole in bushing, reamed out,

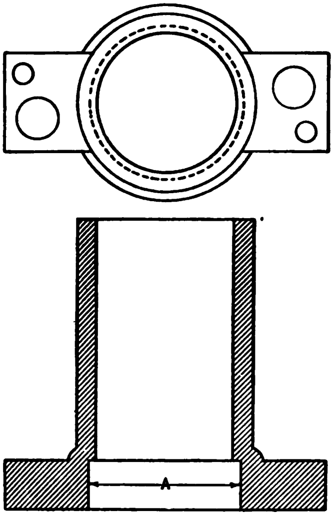


FIG. 114.

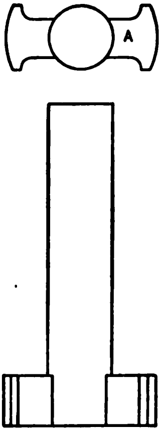


FIG. 115.

it was used to steady the reamer for sizing the drilled hole in Fig. 116.

Second, an arbor was made to fit this reamed hole, having at its opposite end a tapered sleeve, made in halves, to fill the varying sizes of holes in Fig. 116.

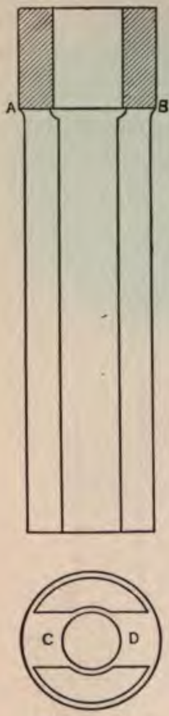


FIG. 116.

This sleeve was made in halves because the two legs of each stool, not being of the same rigidity, did not spring equally when the bushing for drilling and reaming the upper end of Fig. 116 was forced into place.

The arbor was first pushed through the reamed hole and the half-sleeves slid into the lower end of Fig. 116, until each half was nicely in contact with one of the legs, then the clamp-ring was placed over casting and tightened. This clamp was a plain ring with a set-screw tapped through it; the screw, with a stud in face-plate, made a driver for the work.

Thus we were able to hold this slender casting between centres and finish the two ends and outside, above AB, true with the hole.

The jig shown by Fig. 108, and described in Chapter II., was used to space and drill stripping-plate for this job.

The hole D through pattern-plate C, Fig. 111, was made of the size shown by dimension A, Fig. 114. This gave piece Fig. 115 the support of the pattern-plate.

Castings made from this set of patterns, and from the set described in Chapter II., were fine examples of the patternmaker's skill.

Plates B, C, and X, Fig. 111, correspond to those with similar letters in Fig. 107. Pattern-adjusting screw is lettered Z in both figures, while the loose collar A, Fig. 111, is used for fixing the amount of lift, instead of screws, as shown at H, Fig. 107.

CHAPTER IV.

A VIBRATOR-PLATE PATTERN.

THE pneumatic tool, technically known as a "vibrator," and which gives, in the brass-foundry, the same or better results than the long roll played by the helper, with two rammers, on the inside of the sand-trough, enables us to successfully mould many pieces without going to the expense of stripping-plates. One of these castings is shown in Fig. 117.

This casting might be parted through the centre line of its length, but this would leave the joint of mould all the way around nut, making more work for the polisher. It was therefore decided to make the parting follow the corner A. This makes a crooked joint, as is seen by examining any hexagon nut made with chamfered ends. How to make this pattern is shown below.

Fig. 117 shows a sectional view through largest diameter of nut, and a plan view. By inspection of the plan, it will be seen that the middle of flat side has a height equal to whole height, or thickness, of nut. Therefore, the parting in mould would range between A and B, while the parting in core had best be on line C.

It will be noticed that letters are used to denote dimensions in the figures illustrating this chapter, the same letters being used through all of the figures.

Fig. 118 shows two pieces: the nut, 1, complete as regards the outside, but having only the larger end of core cut out, D diameter, and G depth. The end of nut is chamfered on the inside, at the end of opening, as shown at L; this strengthens the core by doing away with the sharp angle which would otherwise occur at this point. The flat sides and the inside of D require a little draft. The other piece, 2, in this figure, is a ring bored to fit over the chamfered end of nut, as shown in the figure, with

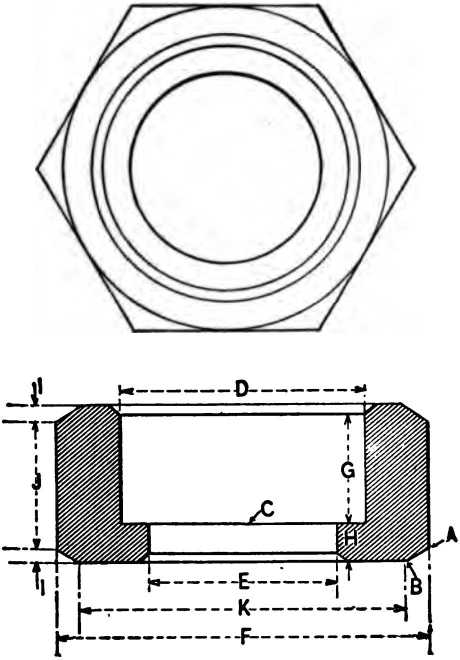


FIG. 117.

the outside diameter ½″ greater than largest diameter of nut, as is indicated by the dimension F+½″. The thickness of this ring must be equal to amount of chamfer on nut, 1. When these two pieces are placed together, as shown in Fig. 118, the chamfered ring fits over the nut and leaves pockets at each flat side. This arrangement makes the parting line follow the corner, A, Fig. 117, and thus forms the crooked joint necessary. These pockets are shown very plainly in Fig. 119, which is a section through flats, or shortest diameter of nut. The pockets, shown at their greatest depth, the thickness of ring 2, are seen at M.

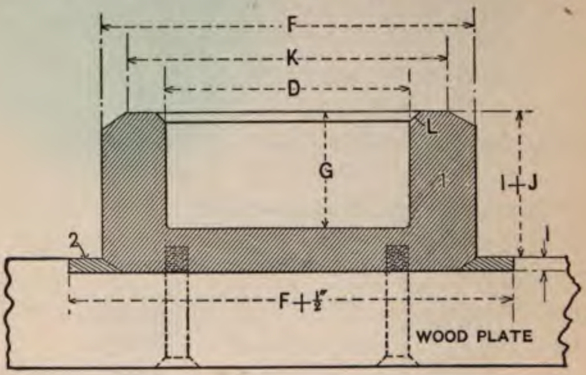


FIG. 118.

For the mating part of this mould, the pattern 3, Fig. 120, is required. This leaves a cavity in the mould which fits over and around the six little projections of sand, formed by pockets M, Fig. 119, for each nut in the set. As these projections would be very easily crushed in closing the mould, and thus ruin the castings, the piece 3, Fig.

120, is made slightly larger in diameter than the nut, as is indicated by the dimension marked F+1-64″.

Part 3 has the flange thickness, marked I, of same thickness as ring 2, which also has the thickness marked I. Part 3 also completes the core by means of the cavity, E diameter, and H depth. The projection, N, on bottom of Fig. 120, is merely for centring and locating part 3.

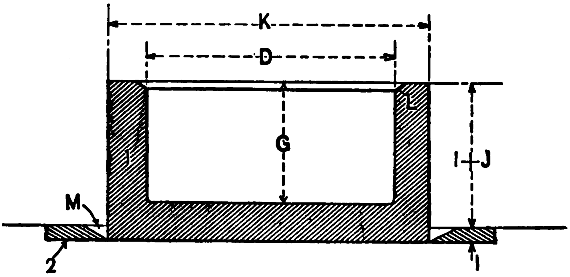


FIG. 119.

As many sets of Figs. 118 and 120 were made as would be required to fill the flask, three pieces in each set, as shown.

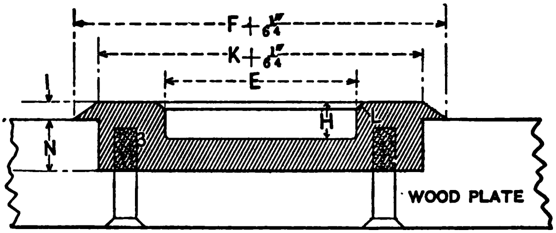


FIG. 120.

This set of patterns was fitted into a pine plate, the plate being first made weather-proof by saturating with hot paraffine.

The plate was then laid out by spacing the centres of patterns, working from centre lines. After the centres were marked, the plate was chucked in the lathe, bringing each pattern centre successively to the centre of the lathe, and then fitting in parts 2 and 3 as required. Part 2 is fitted down flush with the surface of plate, and part 3 let in until the flange rests on plate.

The patterns were made of brass, that the completed plate might have weight, thus doing away with the necessity of fastening the plate down to moulding machine.

The patterns might be made of wood, but they would then be so light that the moulder would have trouble in separating the mould from the patterns and plate, which is, as all patternmakers know, a vital point in foundry work.

CHAPTER V.

THE EVOLUTION OF THE GLOBE VALVE CORE-BOX.

PATTERNMAKERS are perhaps as a rule fully up to other tradesmen in the matter of progression, and instead of making all sizes of globe valves after the style shown in Chapter X. of Part Fourth, as regards cores, we now produce castings up to 6″ and 7″ sizes without making the cores in halves, or in the expensive box shown for the 16″ valve.

It will readily be understood that the 16″ style of box becomes a very fragile and delicate affair when made for small valves; it being extremely difficult to make these small boxes durable, and keep them in good repair.

The patterns for the small sizes are, in most respects, like the 16″ already illustrated; the principal difference being that the small ones are not made hollow. All that has been said of the 16″ pattern, after gluing up, will apply to the ones now under consideration. But when we come to the core-box, that which applies to the 16″ valve does not fit this case at all.

The box, or boxes, there being two required, in general use now, make the cores as shown in Fig. 121. Before describing this box, I shall refer briefly to a style of box which enjoyed a short and brilliant career, but had no staying qualities.

This box I have endeavored to illustrate in Fig. 122. It was commonly made of wood, although some were, I believe, made of cast iron. It was in six pieces, four of wood and the other two smaller ones of brass. The brass parts formed the seat and dividing partition. *The core,* when taken from the box, was complete, and

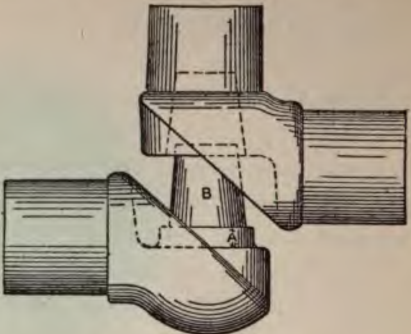


FIG. 121.

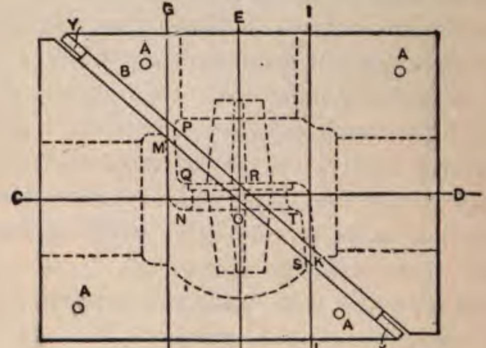


FIG. 122.

only needed baking to be ready for the mould. The manner of production was as follows:

Referring to the 16″ box, which parts the core in a plane parallel to the spindle of the valve, we have only to make the two half-boxes, each from a single piece of stock and without the "half-moon" and "wings," to illustrate the first move in making the box shown in Fig. 122. After the two pieces of stock are squared up and jointed together, they are fitted with four dowels. *A A A A*, two each side of the angular partition, *B K*. Lay down on the joint face of the half without pins the centre lines, *C D* and *E F*, and carry them over to the side opposite the joint, which side should be strictly parallel with the joint.

Lay down the two lines marking the thickness of the angular partition, carrying them entirely around the box; then locate the half-box on a face-plate by centring the intersection of lines *C D* and *E F*. After testing in the lathe to see that it is centred correctly, fit on the other half by its dowels, and mark the centre on the outside, or turn a shallow recess to fit a face-plate; thus matching the two halves for turning out the body sphere.

If you are now careful, in turning, to make both halves of the same diameter, they will match nicely at the parting. A circular templet, turned in the lathe, is best for testing the box while turning; and a depth gauge, set to one-half the inside diameter of ball, makes it possible to use the complete circle as a templet, without crossbar or line to gauge the depth.

The three ends, *C*, *D*, and *E*, may also be bored out in the lathe, if your lathe is equipped with a slide rest; in fact, the entire box may be finished in the lathe as was the custom for core-boxes for small and medium sizes of valves. The only parts worked by hand were the round corners where the three ends join the globe.

The box should now have four holes, two in each half, drilled through parallel with the joint, on lines *G H* and *I J*. These holes must also be parallel with centre line *E F*, and for a 2″ valve, they should be ¼″ diameter. Use brass rod for these dowels, and place them so as to leave the distance from *K* to outside of box at *L* a little more than the length of *B*, the piece shown in Fig. 124.

The fifth piece, *K*, of brass, for a 2″ valve, should be ¼″ thick. This piece was a casting, the pattern for which was made in this way:

A squared block of wood is fastened to a face-plate and bored out to receive the pieces *A* and *B*, Fig. 123, which pieces are turned up as a split pattern, with the end *C* like the outline of seat *M N O*, Fig. 122. Then the face of block is carefully cut away, on the angle of partition, until the cavity left in the face allows the piece *A* to enter to the depth which the seat, *M N O*, projects beyond line *B K*, Fig. 122. This line will be the face of the completed chuck. Then fasten a small piece of wood in the cavity in such a position that after it has been cut off even with the face of chuck, the centre can be located and centre lines marked across the face at right angles, using the squared sides of block as a guide for so locating them, the block having been beveled so that opposite sides are of even thickness.

Now get out the plate *B K*, and draw centre lines, one *for the* joint of the box, and another at right angles with the first, on each side of *B K*, where the line *E F* intersects either surface of *B K*. Locate the plate on the chuck by these centre lines and fasten. Bore out until the piece *A*, Fig. 123, will go through to its place in chuck; now turn plate *B K* over, bringing the edge which was on thin side of chuck to the thick side of chuck, and locating by the centre lines, fasten and bore out to fit piece *B*. This piece may now be glued to the plate,—be very careful to keep it central. After the glue is dry, cut off all of *B* that projects above the surface of plate *B K*, and turn plate over to its first position. Glue in the other half, *A*, of seat, cut off even with the plate, and then bore out to line *P Q R*, Fig. 122. Again reverse the plate and bore out to line *S T O*, this time boring through seat, for opening, and rounding corner, as at *T*.

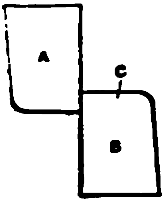


FIG. 123.

Now take the piece from chuck, and after rounding the corners where circular seat comes to the surface of plate *B K*, finish with shellac and send to the foundry for casting.

Note this point: if the piece *B K* has been correctly made, the thickness through seat is as much greater than thickness of seat *A* in Fig. 126 (which is a core of the same size as the one made in box shown in Fig. 122) as the thickness of plate *B K*, when measured on line *E F*, is greater than thickness of angular partition measured on the same line. This extra thickness is taken up by the disk *A*, on anchor mould, Fig. 124, the piece *B K*, being recessed on top side to receive this disk, as at *R*, Fig. 122.

The space between lines for angular partition is now cut away and brass plate *B K* located and drilled for the ¼″ rods. These rods may now be fastened in the box; the rod *G* fastened in *C* end and rod *J* in *D* end. Having the plate *B K* in position, put the piece *X* against the edge of plate and fasten securely. Repeat this operation for *Y* and fasten to other end of box. These pieces, bearing against the edge of plate, hold the parts of box firmly in position, and as they are made the exact thickness of angular partition, they also serve to bring the ends *C* and *D* into line after plate *B K* has been removed.

The sixth and last piece of box is the anchor mould, Fig. 124, made of brass, the two ends being alike on each side of the centre disk, *A*. The pattern from which this is cast can be used for the anchor shown in Fig. 125, by removing the disk *A*, 125 being exactly like 124 with disk removed and the ends brought together.

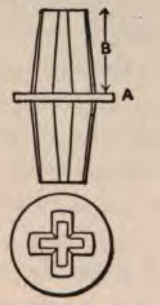


FIG. 124.

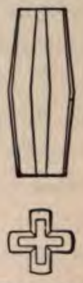


FIG. 125.

In making the core, the end *C*, which is the inlet end *of valve,* is made first, the plate *B K* and piece 124 being in place. Then the box is laid with *F* side down, end *E* is put on and box filled up, the print finished and nailed. With side *G E I* on core-plate, remove end *C*, leaving plate *B K* down. Set this part, with core still in box, down on print end *C*, then draw off plate *B K* and remove anchor mould, 124. Daub an anchor, Fig. 125, with paste and set it in part *D*, put on inlet end, and having removed clamps, draw the box away from core, leaving the completed core standing on end *E*, ready for the oven.

I have been at some pains to describe this obsolete form of core-box because nearly the same operations are gone through in making the wooden masters for the core-boxes in use to-day.

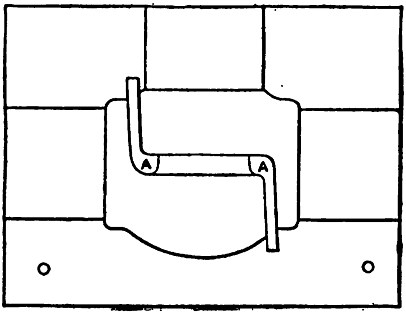


FIG. 126.

Still another form of box for the small valves is shown in Fig. 126. These valves have what is technically known as a "bibb" seat, that is, like the seat of a compression bibb or faucet. This seat, *A A*, was formerly made to draw out through the side of the box, and all of wood. The next step was to make the slides, *A A*, of brass. Then the box was made of cast iron and the slides cut through. The cast-iron boxes were at first made from square, solid blocks, and after being planed up and dowelled together, the outline of core was laid out on the joint side, but before cutting the box out (this cutting was done in the lathe after the manner described for the wooden box, Fig. 122) the seat was laid out, cut through both halves and the slides fitted.

These openings were then filled with lead to prevent the corners from chipping off when working out the inside. Rather an expensive box, but this was improved upon by casting the two halves from wood or plaster masters, then laying out and fitting the slides from the outside of box. This was again bettered by casting the half boxes complete with seat, from plaster masters, which is the present method.

Some foundries will prefer metal patterns, which may be made from master patterns, allowing for the extra shrinkage and also for finish on patterns where necessary. It is well to have the flanges loose, and flanges may also be made of wood to lessen the weight of pattern. The grooves for locating and holding the flanges in place should be finished in the lathe, as should also the prints. If patterns for use on a moulding machine are required, this same master may have flanges fitted, and the entire pattern made of cast iron.

The iron patterns should be lightened by coring out the inside, and to accomplish this we shall need a core-box. This box may be quickly and cheaply made of plaster. We must have a core-stick exactly like the core *needed,* but as the inside of pattern need not be made to exact dimensions, we need not spend much time in sizing the stick. Make calculations for dowel pins and rapping holes in the iron patterns if they are wanted for floor moulders. If they are for the machine, no rapping holes will be required. The pattern should have a dowel at the end of each print and one place for rapping at the centre of its weight.

After the core-stick, commonly called the lightening core-stick, is finished with at least two coats of shellac, give it a good surface, for it will not work well unless it is smooth; make a frame, like a box without top or bottom, large enough to hold the stick and leave a margin of not less than half an inch on all sides. The depth of this frame should be half an inch greater than the greatest depth of stick. Give the core-stick a good coat of tallow. Don't use oil, because it runs off and fills up the corners. While this would be no serious matter in a core-box of this kind, it would spoil a regular core-box, and it is well not to form the habit. Don't put the tallow on an eighth of an inch thick, but be sure that every portion of the surface is greased; if you miss any part, the plaster will find the dry spots, as you will discover to your sorrow.

Make ready a surface plate as large as the box you are going to make. As this may be used over and over again, it will pay to make a good one. It should be well varnished to make a good surface, and prepared with a coating of tallow to prevent the plaster from sticking. Now place the stick with its flat side on surface plate and fasten it down. As the plate forms the joint side of box, we should take pains to keep the stick, and also the frame which will form the outside of box, down on the plate. The stick may be held down by a screw, put through the plate from the bottom; and the frame can be held by handscrews. To this end the plate should be held up from surface of bench or floor by strips of wood fastened to its bottom side, and high enough to keep the handscrews from striking. These strips also keep the surface plate flat, thus serving a double purpose.

We are now ready to mix the plaster, and, if you have never made any plaster moulds, you had better experiment a little in order that you may learn how to get the best results. A good general rule is to mix the plaster as thick as it will run. It should also be mixed thoroughly and as quickly as possible. Test by the appearance and also by the touch. You will find that you obtain the best results when the plaster is so mixed that it feels and looks greasy when ready to pour, and it then sets very quickly after pouring. The proportions of plaster and water depend a good deal upon the freshness of the plaster, as does the time required for mixing.

Well, supposing that you know all about plaster (I don't), or have learned by this time; mix your plaster and pour; then, as soon as possible, strike off the top of your mould, which will be the bottom of the completed box, and nail on a board to protect the plaster. After removing handscrews and screw in core-stick, turn over the box, and after thoroughly rapping the stick, draw it out. You will now be able to appreciate some of the difficulties which beset the moulder's way, although your plaster mould will not break up as easily as his sand mould; to offset this the sand mould, by rapping, becomes a little *larger than* the pattern, thus facilitating the operation of drawing the pattern. The plaster mould cannot be enlarged by rapping, but if you have greased the stick thoroughly, it will come out readily enough, then the box should have two or three coats of thin shellac, when it is ready for the core-maker.

After experimenting with the lightening core-stick and box, we are now ready for the more important regular core-box. It is proposed to make this box of plaster, and to use the plasters as patterns to get iron castings, which, after being jointed together and dowelled, will make a first-class box, and a *cheap* one.

The boxes: I say boxes, because the best and cheapest way to make globe valve cores is to make them in two parts, like Fig. 121, and paste them together after they are baked. This will require two boxes, and they need to be very nice; therefore make them of plaster.

For the core-stick we shall want stuff got ready to make two pieces like Fig. 127, two for 130, and one for 129. The two like Fig. 127 are to be jointed together and turned like a split pattern, making, as seen by referring to the illustration, one pipe end and the ball or globe. The ball should be turned as nearly as possible with its centre, or axis, exactly in the joint. The dimensions should also be very accurate, making due allowance for the shrinkage of the iron box which is to be made from the plaster patterns. Separate the two parts, and chuck one of them, Fig. 127, with the ball in the centre of the lathe, and the flat surface of joint perfectly true. When this is done, if you centred the piece exactly in the joint when it was turned up, you have now put it in the lathe at right angles with its first position, with the centre line of lathe perpendicular to the plane of the joint. The other half should now be placed upon 127 and fastened. Now bore through the last piece to the outside diameter of the cell-like partition which surrounds the seat and separates the inlet from the outlet, marked by the broken line *a*, in Fig. 128. Then, removing this half, we finish 127 by carrying the bore down to the bottom of the seat, indicated by line *b* in Fig. 127.

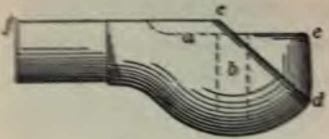


FIG. 127.

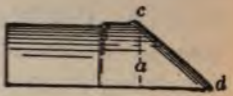


FIG. 128.

The seat of a globe valve, in most cases, comes in the centre of the ball. In a case where it does not, this part, Fig. 127, should be cut down an amount equal to the greatest distance which either side of the seat may be away from the centre, and a thin plate of wood fitted in the recess to bring the surface near enough to the centre of the ball to correspond with the other side of seat. Bore the small hole, marked *b*, through 127. This completes the lathe work on these two pieces, so put on a coat of shellac and proceed with 129.

This piece forms the yoke or hub end of the core-stick, and the print is made tapering so that it may draw easily out of the box, as will be shown further on. It will be seen by the broken lines in Fig. 129 that it is hollowed out to fit over the ball and has a pin at the centre turned to fit *b*, Fig. 127. This serves to bring 129 central with *127* when making the yoke end of box. Give the part shown in Fig. 129 a coat of varnish and pass on to Fig. 130. There are two views of this piece for the reason that, while all other parts shown are circular, except that portion of Figs. 127 and 129 marked by lines *c d*, which is a flat surface or plane, extending across the valve at right angles with its length, this piece, Fig. 129, is sometimes made with a flat side, as is shown in the plan view. (This part of the stick is sometimes made square and sometimes round.) The largest diameter of Fig. 130 is equal to that of the hole which is to be cast through the seat of the valve, while the distance from *a* to *b* marks the thickness of the seat in the casting. The rest of this piece shows the pin which is to be formed on one part of the core to enter a corresponding recess in the other part, while the flat side (or square) brings the two parts into line when the cores are pasted together. The amount taken off to form the flat side is found by dividing the circumference of the pin into four equal parts and cutting off one of them. In other words, the flat side in the plan view is a chord of 90 degrees of the circumference of the pin. This gives ample surface without

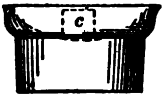


FIG. 129.

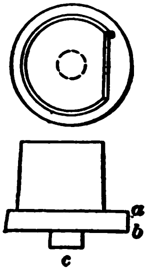


FIG. 130.

weakening this important part of the core. As this pin can be no larger than the hole through seat of valve, it will be seen that, in making small valves, this becomes a very important consideration.

This piece, Fig. 130, also has a pin, *c*, to fit the hole *b*, in Fig. 127. The shoulder at *a*, Fig. 130, affords another guide for the core-maker in assembling the cross-together, and it will be found that this shoulder affords a much better guide for the thickness of the seat than does the fit of the pin.

Now, returning to pieces 127 and 128, draw a line around the ball at the angle shown by the line *c d*. The plane represented by this line must be at right angles with the length of the valve. To draw this line, make a templet by fastening a thin piece of wood on a face-plate, and, after turning one side true, bore a hole through the piece of the same diameter as the ball of core-stick. Then lay off on the stick the points *c*, Fig. 127, one on each side at joint, measuring from the joint, which is also the centre, to correspond with the drawing of valve, and two points, *d*, Fig. 127, which mark the intersection of the angular partition with the ball. These points must all be taken from the drawing, and all must be half the thickness of angular partition from the centre plane of ball.

Now, having four points in the desired line, by applying the plane templet so that it will touch all four, we may draw a line around the ball in the desired position.

Piece 128 may now be quickly finished. All that remains to be done is to cut it off to the line *c d* and round over the corners formed by the junction of the plane surface, *c d*, with the circumference of the cell marked by the line *a*, and the angles at surface of ball.

Piece 127 requires a little more time. There must be left at *e* a circular projection having the same centre as the cell *a*, Fig. 128. This centre is in the line *E F*, Fig. 122, but has a radius equal to that of *a*, minus the thickness of cellular partition. This difference of radius should be the same at correspondingly equal distances, measured in opposite direction from the plane surface *e*, Fig. 127. The circumference of this projection may be drawn upon the surface marked by line *a e*, and then worked down, using a bevel to get the correct taper, but because of the constantly varying depth of surface of the projection, which makes the use of a bevel or templet with a blade of fixed length anything but nice, a much better way is to turn a piece about three inches long, having its largest diameter equal to diameter of projection on line *a* and having the right taper, not forgetting to leave a pin on the large end to fit hold *b*, Fig. 127. This plug, being placed on the surface *a*, with its pin in hole *b*, gives us at once the diameter and the correct angle. The projection may then be worked off to match, with the help of a straight-edge.

Then taking care to make the surface *c d* a plane surface, and leaving a fillet at the intersection of plane and projection, we may finish up this piece very nicely. Round off the corners at *e* and *c d*, the same as was done on piece 128. The fillet should be of the same radius as the round corner.

These pieces, 127, 128, 129, and 130, should all be finished with at least two coats of shellac, making them, if possible, a little better as regards surfaces than a regular pattern, and you will be repaid for your trouble when you come to the plaster work.

Now we shall want a box equal in length to Fig. 127, plus one inch; in width, to the diameter of ball plus two inches, and in depth to the combined height of pieces 127, 128, and 130. This box must be put together with screws; no bottom is needed.

To make the first part of plaster core-box, the hub or yoke end, Figs. 132 and 133, we shall need a wedge-shaped piece that shall fill up the space between the continuation of line *f c*, Fig. 127, and *c d*, or as near *c d* as the rounded corner will permit.

By laying the part seen in Fig. 127 on the plaster-board and trying a square around the outside at *c d*, we may find the largest points on core-stick. These points will mark the joint in core-box, and the rounding of the corner should be so done that the points shall come in a straight line when viewed in the position of Fig. 127. The wedge-shaped piece should be cut to lay on the board and come up to the line marked by these points; continuing the inclined surface, *c d*, ¼″ beyond *d*, and then cutting off parallel with *f c*. This piece and part 127, when laid together, should just fill the length of box. It would be well to give the inside of box and inclined surface of wedge one or two coats of varnish.

Put the part shown in Fig. 129, in place of 127, and coat them nicely with tallow; then the surface of board, the inside of box, and inclined surface of wedge are all to have a coating of tallow. Fasten 127 on the board *with the* wedge under *c d*, and put the box over them.

Mix and pour the plaster, filling the box to a level with end of print on part 129. Remove stick and plaster from the board and trim off any surplus of plaster at the end of print on 127, also at the joint *f c*, and draw out the stick.

You will now have a block of plaster like Fig. 131.

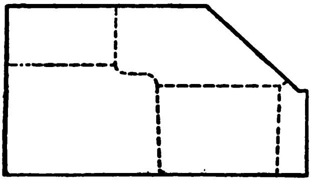


FIG. 131.

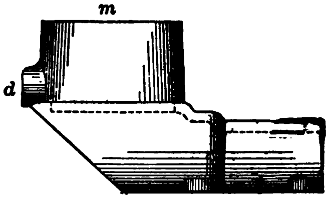


FIG. 132.

Give the inner surface a coat of shellac. Be careful of the corners, because we all know that, while fins are really necessary to fishes, they are neither useful nor ornamental on cores.

Now go over the surface of pieces 127 and 129 again

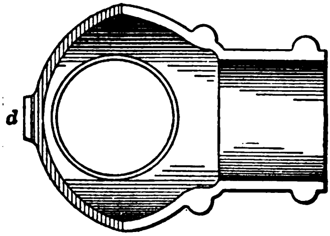


FIG. 133.

with tallow, put them back into plaster block 131, and coat the surface which was in contact with the board and wedge, and which forms the joint of core-box, with tallow. Lay the plaster and stick on the board with *f c d*, Fig. 127, *up* this time. Put the box back in place around them, not forgetting to tallow all parts which plaster will touch.

Piece seen in Fig. 128 is now to receive a coating of tallow, and is then fastened to 127 by a wood screw through core-print and a nail through each of the points, *d;* then plug hole *b*.

We are now ready to cast the second part of box, see Figs. 135 and 136. Fill up with plaster, this time, to half an inch above *c*, Fig. 128. Remove box and scrape off surplus at end of 128. The two blocks of plaster may be separated by laying on the side and gently tapping on end of core-print, Fig. 129. This second plaster *will be like* Fig. 134.

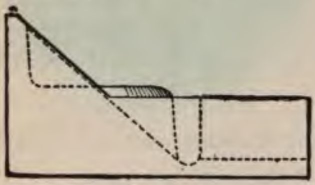


Fig. 134.

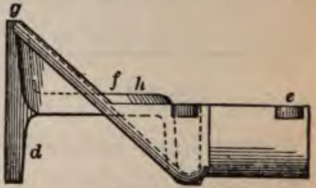


Fig. 135.

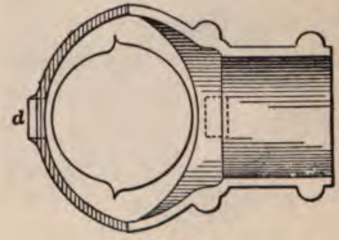


Fig. 136.

Once more we go through the same operations, using plaster 131, and sticks 127, 128, and 129. Remove the plug from hole *b*, and substitute in its place piece 130. This part should be placed with its flat side at right angles with the length of stick.

Fill up the box to the top of piece 130, scrape off even with 130 and 128; the resulting block of plaster this time being like Fig. 137.

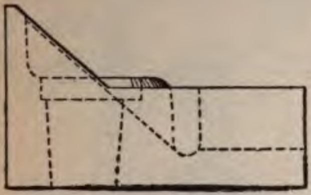
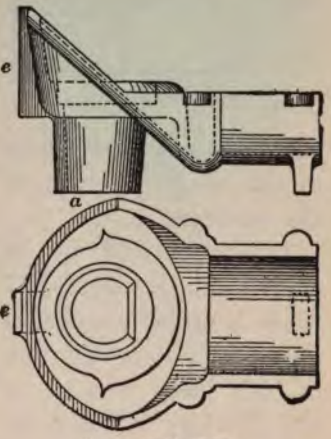


FIG. 137.



FIGS. 138, 139.

For the fourth and last cast, lay piece 135 on the board, with sticks 130, 127, and 128, leaving off 129 and plugging hole *b*. This time the plaster is like Fig. 140.

These plasters are now to be cut off to the shapes shown in elevations 132, 135, 138, and 141, and corresponding plans, 133, 136, 139, and 142.

For a 6'' valve the plaster patterns should be about $^{3}/_{8}''$ thick. Each part to have lugs for dowels, four in number and large enough for $\frac{1}{4}''$ dowels, the lugs being left about $^{5}/_{8}''$ thick and having a projection beyond outside of box of at least $\frac{1}{2}''$. As to the shape of outside of plaster, keep the thickness as near uniform as possible, not forgetting the core-maker, who will need a place to put the clamp on and will want each box to stand alone, with the open ends up. For these purposes, Figs. 131 and 134 have the projections at *d* left on, and pieces 137 and 140 have *e*. These four plaster patterns are to be varnished and handed over to the tender mercies of the moulder.

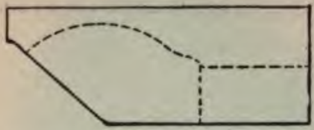


FIG. 140.

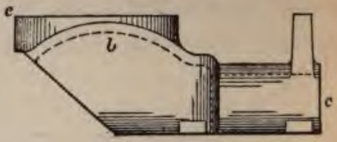


FIG. 141.

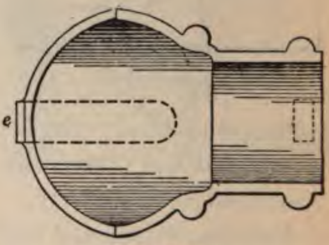


FIG. 142.

There remains to be made a pin like Fig. 130,* which is properly a part of Fig. 134, but is not cast on this piece because of the difficulty in finishing, and in so locating the flat side that when the two cores are put together they shall be straight. I make this pin of brass, leaving stock for finishing all over; plenty on all parts that can be turned and but little on the flat side, that it may be finished with a file. For a 6″ valve, make this pin in two pieces, as shown by Figs. 143 and 144; making 143 so that it will be ¼″ thick after finishing, and 144 with the round pin 1″ in diameter.

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*Fig. 130 is for a valve without seat ring, the enlarged collar between *a* and *b* taking its place. This collar is wanting in the pin *shown in* Figs. 143 and 144, this pin being for a valve *with* seat ring.

Now as to finishing the castings in making up this box: begin with 135, filing *f g* down to a surface plate, without removing any more metal than is necessary, then cutting down *e f* until you have only the half of the full circle of print left. At the same time be careful to keep the two sides of the box the same distance from the top of seat at *h;* also clean off the top at *g.* Now fit part 141 to 135, being careful not to cut off too much iron at the joint of box; using a pair of calipers to fix this point.

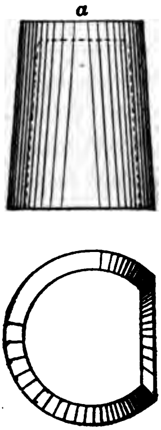


FIG. 143.

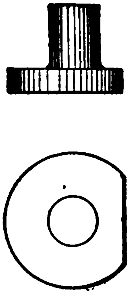


FIG. 144.

After 141 has been fitted to 135, 138 should in turn be fitted to 141, using the inside calipers at end *c*, Fig. 141, and a depth gauge set to the correct distance for end *a*, Fig. 138, from the surface *b*, Fig. 141. Clean out the hole left by pin 130 in piece 138, then fit brass pin, pieces 143 and 144, to this hole; having first fitted 144 down into the open end of 143. Set 144 down about

½″ below end of 143 and solder strongly in place. Then finish the two, 143 and 144, between centres, to fit 138. Having fitted these, first to diameter of hole in 138, then to length, leaving end *a*, Fig. 143, about ¼″ long, turn the pin on 144 to ⅞″ diameter, cut it off a little short of the thickness of 135 at *h*. We must now centre 135 very carefully and drill hole to locate brass pin, which is to be fastened in place by a cap screw and washer, underneath *h*.

Now fit 132 to 135, testing from time to time to find if the brass pin is coming central with opening *m*, in 132, using the inside calipers at end *e*, also the depth gauge, set to correct distance for end *m*, Fig. 132, from surface *h*, Fig. 135. As the pin, 143 and 144, forms the hole through the seat of valve, it is evident that when it is central in opening *m*, the yoke opening and the hole through seat in casting must come true.

Drill dowel pin holes in parts 131 and 141, from the joint side. Then fasten the halves of the two boxes together with solder, 131 and 135 making one box, and 138 and 141 the other. By handling carefully, the solder will hold while drilling the dowel holes back through 135 and 138.

The boxes may then be broken apart, and dowels of hard steel wire driven into parts 135 and 138. These dowels should be made with a slight taper in order that they may be adjusted from time to time to compensate for wear.

The brass plug should now be removed and the four pieces of core-box heated until they will melt paraffine wax, which should be applied to the inside surface to prevent rusting. After the parts are again cooled, scrape off all superfluous wax and fix brass plug in place, with its flat side at right angles with print *k*, Fig. 135, and send the boxes out for a sample core.

This sample core should be furnished in two pieces, that is, without pasting together. The cores are now put together dry, and tried by a straight-edge to find if the prints, *e*, Fig. 135, and *c*, Fig. 141, come in line; if they are not in line, turn the brass plug in its hole in 135. If the plug is made round it may be fitted more readily and accurately to the hole in part 138; neither will there be the trouble of locating the flat side to fit mating surface of 138, which might be a little off square, and the round plug will hold just as well after pasting as the one with the flat side.

If you find, upon examining the sample core, that in fitting plug you have not made proper allowance for the physical development of the core-maker, and the pin *B*, Fig. 121, is too large for the hole left by the plug in the other part of core, you may correct this by either cutting off end of plug which touches surface *h*, Fig. 135, if the hole is too large; or by putting a thickness of sheet metal under this end if hole is too small.

After getting a sample core that tests out all right, drill and dowel the plug to part 135 if it is made with a flat side as illustrated by Fig. 130.

CHAPTER VI.

MULTIPLE CORE-BOXES.

IN the continuous and universal effort to reduce the cost of cores, the multiple core-box has always been a favorite device.

The multiple box saves time by enabling the core-maker to ram up two, four, or as many cores as the box may be arranged for, at once; each necessary operation being performed in less time because the workman is not obliged to go through the whole cycle of motions for each separate core.

A single handful of sand may be sufficient for a dozen cores; and it would, of course, require the same time to pick up one handful whether the box made one or a dozen cores.

If, for example, the box makes five cores, as in the one illustrated by Fig. 147, the core-maker has to drop his rammer and pick up his strike but once instead of five times, as would be necessary for a box making but one core. When the box is made for a greater number of cores, the advantage is also greater. In fact, the saving is so apparent that it requires no explanation.

I don't know when the first multiple box was made, but it must have been very soon after the first core was used. My first experience was with boxes for oil cups, such as are shown in Fig. 145.

These had been made for a single core, and as the pattern had but one print, this print had to be long enough to balance the core when setting and to hold it securely in place when the mould was poured. It must also have a guide for setting, as the shoulder at *A*, Fig. 145. The core-prints, so made, took up considerable room in the flask, a part of which, it was thought, might be saved by making the cores double, as shown in Fig. 146. The double core would balance itself on the print between patterns, which print need only be long enough to prevent crushing when setting and pouring. The ring at the centre locates the core.

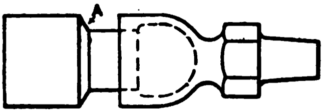


FIG. 145.

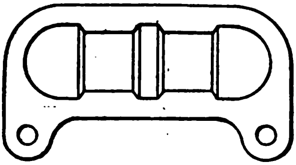


FIG. 146.

This core had to be rammed up in halves, then pasted in the box which was provided with dowels for this purpose. The dowels were placed both at one side as shown. Both were on the same side of box that they might not interfere in striking off the half cores made in the pin side of box. The plan did not result in cheapening the cores, but did increase the day's output of castings.

A very common form of multiple box is shown in Fig. 147, where *A*, *B*, *C*, *D*, and *E* show recesses for straight, round cores. *F F* on the joint view are dowels, and are placed as shown, rather than at opposite corners, to prevent the core-maker from mis-matching the halves when putting them together. This happens oftener with two pin boxes than might be thought possible. Unless the box happens to be drilled so that it matches closely when assembled wrong, the core-maker will see his error and correct it before filling the box with sand. This correction takes time, and as many cores are made on the piece-work plan, the core-maker, as well as the firm, suffers for the time lost. Some core-makers prefer three pins, two at one end and one at the other. This is, perhaps, better than the two-pin plan illustrated. A box with three pins is shown in Fig. 148.

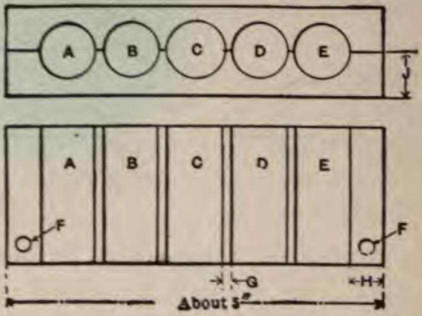


FIG. 147.

The space *G*, Fig. 147, should be as small as is consistent with strength; in most cases it need not be over ⅛", and the dimension *H* must be made to suit the size of dowel used; for ¼" dowels it need not be over ½". Then the total length should not exceed five inches, in order that the half-box may be easily spanned by one hand in lifting off. The thickness *J* of the half-box can usually be made equal to the greatest radius of core plus ¼″. If the cores are large ("large" for this kind of core, would be 1″ in diameter), some of the metal at the back should be cut away in the master, to reduce the weight of the finished box.

For making up such boxes as are illustrated in Fig. 147, a stock of castings—gray iron, of course, is understood—of such dimensions as had by experience been found desirable were kept on hand. When such a box was to be made, a pair of these castings were prepared by planing to the required width (the length of desired core) and thickness. Dowels were then put in and the box, having been laid off by locating the centres of cores on each end, was drilled between centres, from each end to the middle of length of core. A small drill was first used, followed up with larger sizes until the holes were of the required size. The last drill, or perhaps the special reamer, which may be necessary for a core of some unusual size, should have but little stock to take out.

When the cores are as shown in Fig. 148, or of an irregular shape, which could not be readily finished or

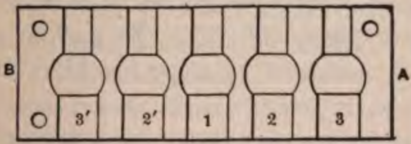


FIG. 148.

produced by the method above noted, the boxes were usually cast from a plaster master-box. This master requires some very nice work on the patternmaker's part, both in making the core-sticks, as they are called, and again in placing them for pouring the plaster, it being understood that only a half-box is made of plaster.

A good point to remember when placing the sticks, which are in halves, is this: As it is quite likely that some, if not all, of the sticks needed—three will be needed for the box shown in Figs. 147 and 148—will, when finished, be found to have one half greater than the other, number the halves in pairs as they are turned; then if the box is to have an odd number of cores, select the most accurate stick of the lot for the centre core, and after discarding its mate, place the others as indicated by the numbers in Fig. 148.

A moment's reflection will show that the half-boxes cast from this master must, in finishing, be assembled so that the *A* end of one will meet the *B* end of its mating half. In so doing it will be seen, by referring to the numerals in Fig. 148, that cavity No. 1 reverses on itself; for this reason the best half-stick was chosen for this position, because any error in thickness of stick would be doubled in the assembled box. Cavity No. 2 matches No. 2′, and 3 matches 3′, thus making the core *round* by bringing together the cavities made from the halves of one *round* stick. To such as are unaware of the skill possessed by some moulders, the accuracy with which such castings are produced seems marvelous.

The cores for Fig. 145 might be made from such a box as is shown in Fig. 148, as one end would be open to view in fitting up and for the reception of sand in making cores. From this box, a saving in the cost of making *cores* would undoubtedly result, but there could be no reduction in size and length of the print, and therefore no increase in the output of castings.

This much-to-be-desired result may be reached by a combination of the principles illustrated by Figs. 146 and 147; the resulting box, shown in Fig. 149, being what

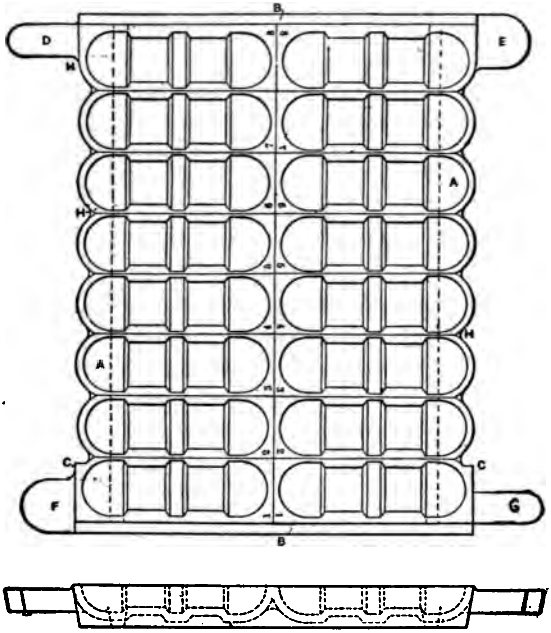


FIG. 149.

is specifically known as a multiple box or shell. How such boxes are made I will now endeavor to show.

It is quite evident that the box shown in Fig. 149 cannot be machined on its inner surface; we shall therefore be dependent upon the foundry for the production of accurate castings. As the moulder cannot be expected to produce a casting which is any better, or more accurate, than the pattern used, he should be furnished with the best possible pattern for such work. These patterns will be expensive, but the results will warrant the expense.

On inspection of Fig. 149, it will be found that one box full of cores will make thirty-two castings, there being sixteen cores, each of which will make two castings. As the castings must be similar, the box must make not only the sixteen cores all alike, but the two ends of each of these double cores must also be exactly alike. The box is, then, made up of thirty-two units, all alike.

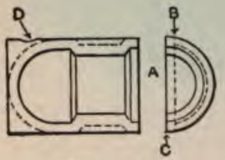


FIG. 150.

This unit, Fig. 150, is made up very carefully in plaster, from which the brass foundry is called upon to make *two* castings. If the plaster could be depended upon to make the whole number of units required, it could be made like Fig. 151; but as it is only ⅛″ thick for this job, it could hardly be expected to last for even the sixteen castings which would then be needed.

After receiving the two castings like Fig. 150, they are jointed together, secured by solder, and through the open end, *A*, accurately finished in the lathe; care being taken to locate the joint between the two halves, exactly in the centre of the lathe. The open end is then carefully squared off and the piece removed from the lathe. File a notch across the joint as at *D*, Fig. 150, for reference in matching up. The halves are then separated and the solder cleaned from surface.

A short piece of stock is now turned to fit the straight part of box at *A A*, Fig. 151. After turning to the correct diameter, one half should be cut away. Do this carefully in order that the piece left may fill but not project above the surface of half box.

The two units like Fig. 150 are then assembled on a surface plate in the position shown in Fig. 151, the arbor being used to keep them in line. After getting them into position and clamping them to the surface plate, which, by the way, had best be kept hot,—how hot? Hot enough to color the brass pieces—solder the two together, sweating the solder thoroughly into the joint at *G*, which will be found easy to do at the temperature noted above.

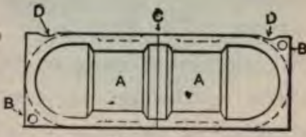


FIG. 151.

Wipe off all the surplus solder and cool the job before removing from the plate. The heating of the plate and the work before the final adjustment is to prevent the work from crawling under the soldering iron, which sometimes occurs when a hot copper is applied to work much below the temperature of the copper. If you are equipped with blast burners, the whole outfit may be brought up to a temperature which will melt the solder and make the use of a copper unnecessary except for the patching up.

The completed piece, now like Fig. 151, is then sent to the foundry for enough castings to make a box like Fig. 149; in this case, sixteen. As the accuracy of the finished job depends in a great measure upon these castings, they should be made with great care.

One good thing for the moulder to observe is that the parting should be on a line even with the bottom of plate which forms the surface of completed box, as at *B*, Fig. 150, and not at *C*. By so doing, the surface *C* and the interior of core-box are in the same half of mould and will not be affected by the closing and weighing of the flask. Use a flask with well-fitted pins, and lift the pattern with the cope if making *C* side down. If moulded the other side up, the cope should be lifted without the pattern. The idea is to get the inside and surface *C* without any rapping or other fault in drawing.

The most common fault with castings, such as are required in making core-boxes, is what is known as "ramming away the corners," causing the casting to appear like Fig. 152, where the rib or fin, which is greatly exaggerated at *A A*, is the fault produced. This is a serious defect, as it destroys the outline of core at the joint of box, so necessary in matching the halves. It can usually be prevented by giving the moulder a little more time for the work. Accurate castings would be cheap at a dollar a pound, and there are plenty of moulders who can produce them. If the castings are well made, their extra cost will be saved in the fitting up, and the final quality and quantity of the work—the cores—as produced by the finished boxes, will be increased.

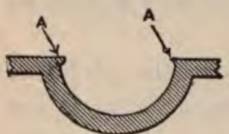


FIG. 152.

The castings, like Fig. 151, are to be fitted up in pairs, matching them together by the reference notches *D D*, *keeping* the notches in each pair, all on the same side of box. This may be done by turning the halves endwise and not sidewise. Dowel each pair together with two small pins, as at *B B*. Number them in pairs, then, taking one-half of each pair, the halves without pins, fit them together as in Fig. 153. These are to be soldered together, but before doing this each piece with pins should be cut to match the outline of its mate.

The halves first fitted may then be soldered together, making one piece of them all like Fig. 153. The pin halves are then assembled on the top of those already fastened together, each individual half or piece being brought to place by its dowels. Some of the pieces will undoubtedly need a little further fitting, so that all may fit nicely in the dowel holes of their mates, without any interference.

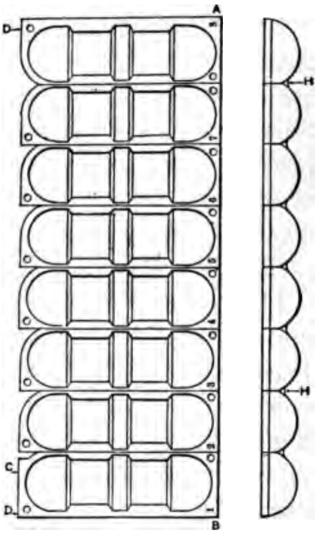


FIG. 153.

Don't try to solder the whole lot at once; add one piece at a time, trying it on and off to test the fit of its dowels, because you must depend greatly upon them for the detection of errors in assembly. If the whole lot are soldered at once and it is then found that the dowels bind, it will be difficult to locate and correct the error. But if the units are added one at a time, making sure of each one as it is fastened in place, any error found may be readily located, as it is sure to be in the last piece joined, and can be corrected by re-locating this last piece.

Having them soldered together in two pieces like Fig. 153, the corners opposite the straight side *A B* can be filed away, leaving one at *C* for reference in final matching up of core-boxes, and also leaving the outside corners at *D D* intact; then the dowels may be knocked out of all but the two outside members. The straight sides, *A B*, are then fitted and soldered together.

It isn't necessary that this last joint shall be so made that the cores in the original halves, Fig. 151, should stand exactly in line in the completed pattern, as the final castings from this master, if mated by the reference piece *C* in Fig. 153, and dowelled so that any one pair of openings match, will necessarily match at all points. The method of building up, always in pairs, carefully matched, makes this result inevitable.

Place the joined halves face down on surface plate, and fit ribs as at *A A*—ribs are indicated by broken lines—and *B B*, Fig. 149. These ribs are for strengthening the box, and also provide a good surface for the box to rest on when in use. Then the ears for pins, *D*, *E*, *F*, and *G*, are fitted and soldered. These ears are placed about ⅛″ below joint surface of box, as shown in end view of Fig. 149, making it unnecessary for the core-maker to clean off *all* of the sand which may lodge on the ear around the pins; thus saving considerable time which may be employed to much better advantage.

Having the parts all assembled, if the castings from *this master* are to be made by a bench moulder, the back of pattern must be finished nicely. Run solder fillets, like *H H*, Figs. 149 and 153, in all the corners on back of master, and make the ribs *A A* and *B B*, and the ears *D*, *E*, *F*, and *G*, with plenty of draft all around.

It will be noticed that the lugs for dowels, *D*, *E*, *F*, and *G*, Fig. 149, are not all of the same shape. They are made as shown to help the core-maker in lifting off the pin side, which lifting must be done very nicely. Fig. 154 shows how the ears match when boxes are fitted up. Each half box cast from the pattern, as shown in Fig. 149, must have two ears like *F*, Fig. 154, and two like *D*. The finished boxes have three dowels, and in the pin half two of these are in the ears *E* and *F*, Fig. 149. The boxes are mated by reference pieces, *C C*, and it is then plain that lug *F* must mate with *G*, and lug *E* with *D*; as is shown in Fig. 154. Lugs *E* and *F* project over the sides of lugs *D* and *G*, but fall short of their ends.

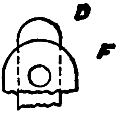


FIG. 154.

The box being ready to lift off, the lugs *E* and *F* of the pin side, which is now the top half, are grasped between the thumb and forefinger of each hand, while the tips of the middle fingers are pressed on the projecting ends of *D* and *G* in the other, or bottom half; thus giving the core-maker complete control over the operation of lifting off.

In the good old times before planing mills were thought of and the farmer who needed a new barn got his lumber "direct from manufacturer to consumer," nearly all farmers and farm-owners had some timber or woodland. If about to put up a new building, the farmer, being a man of sound judgment, would get an experienced person to go into his "woods" and select the trees to be cut down for the frame and covering. The same good judgment exercised all through the job brought about the desired result—a good, serviceable building.

Moral: After spending good money for the master box, don't "let up" until the castings from this box are made.

The multiple box, as so known to-day, is used not only to shape the core, but also as a drier; the half boxes, containing the completed cores, being placed in the oven to hold the cores in shape while drying, or baking. This makes it necessary to have a good many of the half boxes; the number depending on the shape and size of the cores, which size will regulate the time required for baking, and how many, or how fast the cores are needed.

It is plain that all cores made in such boxes must be rammed up in halves. They could be so made from ordinary core-sand mixtures and the halves united with paste; but it has been found from experience that good sharp sand, mixed with linseed oil in proper proportions, makes a mixture which will of itself cement the halves together and also produce a core that stands a lot of handling. The objection that oil-sand cores cannot be handled green is overcome by the use of the shapes or shells for baking.

If the foundry does its part by furnishing accurate castings, the resulting set of boxes—may be spoiled in the fitting up? Oh, yes; but that is not likely to happen. The firm will, on the contrary, be so well pleased with the results that we, the patternmakers, and you, the moulders, will at once get orders to make other sets of these labor savers.

The number to be made up for a set must be left for the user to decide upon; and the method of making the castings will depend upon the practice of the foundry. If it should be thought advisable to fit up the masters for moulding machines, some form of roll-over machine will be necessary for this job, as one could hardly expect to successfully cope out the sand from face side.

As these castings should be poured face down—the face should be as nice as possible, while the back need only be passable—two men may be worked to advantage in the following scheme:

A standard or limit for the outside dimensions of these boxes may be fixed at seven inches wide by ten inches long, exclusive of the ears for dowels. This size is not arbitrary and may be varied to suit conditions. But, as will be seen by what follows, it is necessary to fix some limits to the dimensions, and the size given is as large as has been found practicable. The depth, fixed by the same rule, was that necessary for a round core about 2¼″ diameter. As the different boxes made might have to be poured, some from the seven-inch and others from the ten-inch side, provision was made for this in laying out the rig, by allowing room enough for a pattern ten inches square, plus the ears.

The necessary fixtures for this rig are illustrated, though no provision is seen for attaching the plates, Fig. 155 and 156, to the moulding machine. This, of course, must be arranged to suit the style of machine to be used.

The cuts show only what is necessary for holding the patterns and locating the flask, which may be a snap flask.

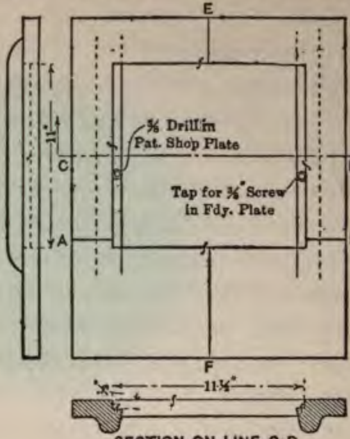


FIG. 155.

Two pairs of plates like Figs. 155 and 156 were fitted up, one set for the foundry and the other for the pattern

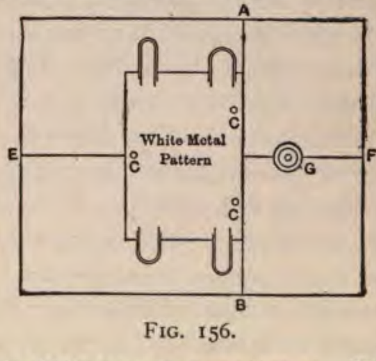


FIG. 156.

shop to use in fitting up new patterns. They were not *strictly* pairs, because the pattern-shop set was to be used as jigs and the foundry set upon the moulding machine. The points of difference are noted in the text and in the engravings.

When made on the machine, the master shown in Fig. 149 was finished on the face side only, as the back, to be made in the core, was a separate pattern, produced in this way: The pattern, having reached the point where the ears for dowel pins are to be fitted on, is secured on a wooden follow, or bottom board, Fig. 157. The surface of this board is recessed ⅛″ deep; the recess being large enough to take any pattern to be made; that is, 10″ square. All patterns have the gating side set to the line *C D*. This line is also one side of the recess, and locates the body of the pattern in position.

After the pattern is fixed in place, the balance of the recess, as at *A* and *B*, Fig. 157, is filled up level with the surface of board. The cope for this mould being perfectly flat, the resulting casting is ⅛″ thinner than the master. The ears, made of wood, are secured in place on the board, being sure so to locate them that the final

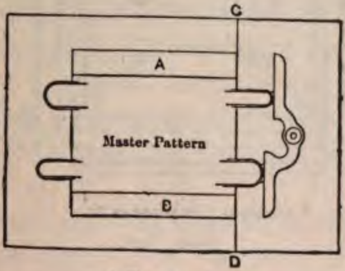


FIG. 157.

castings will match up as was shown in Fig. 154. The fillets on the back are now put in of wax, not solder, as in description of Fig. 149, and the pattern and board sent to the foundry for a white metal casting.

The gate on this board, Fig. 157, may be fast, as it is desirable to gate all of the white metal backs at the extremity of the dowel-pin lugs, as shown. The gate, being fixed, also fixes the length of the ears.

Inspection of the white metal back, having proved it O.K., the master is removed from the bottom board and prepared for the moulding machine by fixing it in a cast-iron box, such as is shown in Fig. 158. A stock of these boxes is kept on hand, machined to fit plate 155. The screw holes, ⅜″, are drilled to the jig, pattern-shop plate 155. Two holes only are necessary. They should be drilled as shown, and not central with side of box. *This* will prevent any error in setting the pattern in

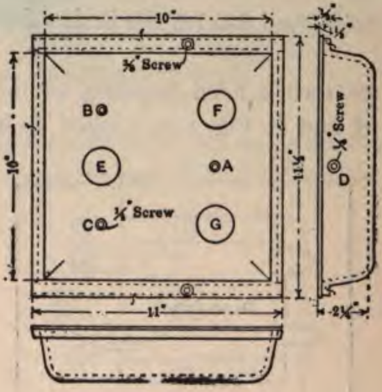


FIG. 158.

plate for foundry. The opening in box 158 is ten inches square.

The master is secured in this box, first by screws through the bosses, *A*, *B*, and *C*, on the inner surface of box at the bottom. These bosses are raised slightly above the surrounding surface, that they may be faced by a counterbore, steadied in screw hole. The screw hole is then countersunk on the outside of box for a machine screw. One-quarter inch is a good size.

Screws passing through these holes secure the pattern in place by entering studs, or posts, soldered to the back of master, and fitted to a length which will bring the pattern ⅛″ above open, or top side of box. This compensates for the amount cut off by recessing the board 157. A line should be scribed around pattern even with top of box for the parting and draft filed to this line.

In locating the master in the box, the edge to be gated is placed directly against the inside of box, as in Fig. 159, where the parts are assembled for the foundry's use. If it has a tendency to spring away from the box, a screw through the side of box, beneath the top flange, Fig. 158 at *D*, and tapped into a lug soldered to pattern, will correct this.

Strips of wood are then clamped to surface of box to cover the openings left on the other three sides, not forgetting the register marks, *B B*, Fig. 159, and the box, which is then turned bottom side up, is filled with liquid plaster, through the holes, *E*, *F*, and *G*, made for this purpose. The plaster sets quickly and secures the pattern firmly in place. It is evident that the box, Fig. 158, with the master fixed in place by screws and plaster, may be stored in safe, and used whenever wanted; making but one plate like Fig. 155, necessary for any number of masters.

The position of nowel side being now fixed, the cope half, for which the white metal casting is used, is placed on the plate, Fig. 156, in a position to match the nowel. A line across the two plates, 155 and 156, as at *A B*, with a centre line at right angles to line *A B* on each plate, line *E E*, will be required. These lines are needed only on the set of plates used in the pattern shop, and are located from the flask pins.

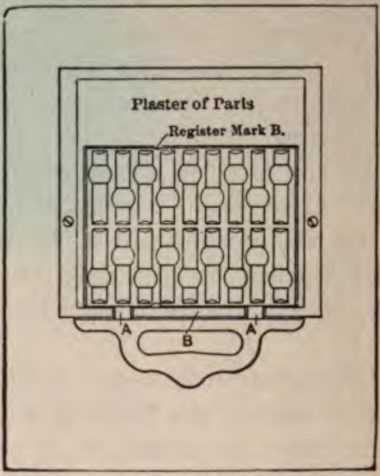


FIG. 159.

The plate, Fig. 156, having been prepared with lines, holes for dowels, *C C C*, are drilled. These holes are all to come within a seven-inch square, located with one of its sides upon the line *A B*, and central with the width of plate.

This location is necessary to insure that the dowels may always come within the outlines of white metal pattern. If it is necessary at times to make some masters which are much smaller than the standard size 7″ by 10″, additional holes may be drilled in the plates. For obvious reasons it is better to make one set of pinholes do for all patterns, and it will usually be found entirely possible to do so.

It is plain, from the location of master box in the flask, it being at one end of the oblong flask, that the cope must always be turned about the line *E F*, in closing mould. Thus, if the mating edges of master and back are placed on line *A B*, they may be centred by the line *E F*, and the perfect matching of cope and nowel made certain.

The white metal back may now be clamped in place on plate 156, and the dowel holes drilled. If these holes are found to come through some thin part of the pattern, a boss of solder may be built around the pin; which should be fast in the pattern and not in the plate. This second plate, 156, is a plain, flat plate, which may be fitted and used upon a machine of the ordinary coping variety, there being no difficulty in making this side. If it is not convenient to use a second machine, this cope side may be made on the bench, using plate 156 as a match board. Either plan will keep two men busy making moulds.

The gate is put on the nowel side, and by making it of the shape shown in Fig. 159, it may be fastened to the plate; the one gate being used for all patterns. The runner is made up for each master by pieces of sheet metal, pinned to the flat edge of box 158, as at *A A*, Fig. 159. This edge, ½″ wide, separates the gate from the pattern; the runners, *A A*, being located where they will best run the casting, and completing the gate by bridging the ½″ gap. The boss for the riser is located on plate 156 to match the gate in nowel, as at *G;* and may also be fixed. If it is thought advisable to gate castings in the way shown by Fig. 157, the gate on nowel plate, Fig. 159, and pieces *A A*, may be left off, and the necessary gate substituted for the boss *G*, on cope plate, 156; the pattern being turned with the ears towards side *F*. For each master so gated, there will then be needed one box like 158, one white metal back for cope pattern, and possibly the gate like Fig. 157. All other parts of the rig being used for each and every pattern, this outfit will be found inexpensive, and also efficient.

The castings made from these masters, whether by machine or bench work, should be rigidly inspected and all imperfect ones scrapped. Warped or sprung castings should be considered as imperfect. While the crooked casting may have a good surface and may be straightened by peening, or by heating and clamping down on a flat plate, the straightening process, whatever it may be, will, in nine cases out of ten, result in the stretching of the concave surface. The crooked casting having been stretched in truing up, is bigger than it should be, and therefore won't match those which required no straightening. Neither should the crooked castings be straightened by grinding or filing away the high places.

This would make the depth inside less, and the cores made in the shallow cavities would be flat. Such cores would not fill the prints, and the castings produced from them would be imperfect.

The finished set of boxes are interchangeable, there being but one furnished with dowels; all of the others fitting this one pin side. In use, two half boxes, one of them being the pin side, are filled with the oil-sand mixture, struck off and the two closed together. Then as they lie on the bench, pin side up, they are rapped and the pin side lifted off, leaving the completed cores in the lower side, which then becomes a drier and is placed in the oven with the cores. By continued use, the boxes, especially those halves used as driers, become coated with the oil sand, and must then be cleaned. A common way of doing this is by washing the boxes in hot potash water.

The pins in these boxes should be fitted very nicely and stand up square with the top surface. This can only be accomplished by using great care in the drilling, for which it is customary to use one of the castings as a jig.

The ears on the castings being 1/8″ below the general surface, there will be a quarter-inch gap between jig and casting at the point where the hole is to be drilled, a bad feature, as any one experienced in drilling will know. A much better way is to provide a plate, on which suitable pieces for locating the boxes are fastened. This plate can be provided with hardened bushings and used for the drier sides. The steel bushings may be removable and used again for other jigs. The bushings project above the surface about one-eighth of an inch.

This jig might be so laid out that it could be used for both drier and pin sides. This would add greatly to its cost and is unnecessary, as one of the driers may be used as a jig for the few pin sides needed. The one selected having been drilled in the jig, may have pieces fastened on the ears to fill up the quarter-inch gap.

It is usual to select the very best of the castings for the pin side, as this side is used, in turn, with all of the driers. The pin side will wear out much faster than the driers; it is well, therefore, to have some extra ones made up against their need.

PART FIFTH.

COST, CARE, AND INVENTORY.

CHAPTER I.

COST OF PATTERNS.

PROBABLY any patternmaker who is familiar with the patterns made twenty-five years ago, or even fifteen, and also with the same kind of patterns as made to-day, has noted the difference in design and also in construction of the work. This difference, where the cost of work is considered, is in favor of the patterns made now. This, of course, is the result of greater experience in the need for and use of patterns to accomplish the desired end. See, for instance, the variety of belt pulleys which may be made from a single ring and spider, with three or four sizes and lengths of hubs. It used to be the custom to make a complete pattern for each size and width of face. Now we make a single iron ring with two or three spiders of different weights, and then a lot of hubs of different lengths and diameter to match the width of face and size of shaft. These hubs and spiders are so made that any hub will fit any spider—not only the different spiders to be used with this one ring—for, of course, all pulleys made of this ring will be of one diameter—but the hubs may be used with any sized ring, as all the spiders are finished with the same sized hole at the centre, into which the hub fits. Thus you see, by having only a few complete patterns, a large variety of pulleys may be made, and made very cheaply.

Another important branch of pattern work has, in some shops, been reduced to almost nothing. This has been accomplished by the use of the gear-moulding machine. The patternmaker used to make the wheel complete in all particulars, except, perhaps, in some rare instances, where different widths of face were made from one pattern. Now the patternmaker cuts from one to three teeth; the best practice uses but a single space, with a part of a tooth on each side; then the machine does the rest, and does it far more accurately than the average patternmaker could. This, you see, makes another great saving in pattern work.

Loam work has done away with a good deal of pattern-work, substituting a few sweeps that are cheaply and quickly made for the costly pattern. All these tend to reduce the cost of pattern work, which is money saved in most cases.

There are some manufacturers by whom the cost of all pattern work is said to be an expense that brings no return—is all outgo and no income; in short, it is a "necessary evil." This class of men get along with just the cheapest (considering only the first cost) patterns they can make. Their castings generally have square corners and no fillets, but they are saving money on patterns to perhaps spend it in the foundry. Now, while it is good policy to make patterns cost as little as possible, don't run to extremes. You can well afford to spend more money on a pattern from which a hundred or a thousand castings are to be made than one from which you want but a single casting. If by letting the patternmaker spend two or three hours rounding corners and putting in fillets you can save five minutes in moulding a single one, isn't that money saved by the time a hundred are made? And on a thousand, a day's extra work would become a good investment. If you try to make a cheap pattern do for such a job as this, the chances are that it will become a very costly pattern before a thousand or even a hundred castings are got out.

If you want a pattern for some repairing or experimenting about the shop, and only intend, perhaps, to make one casting, you would not be willing to spend much time on it. I wouldn't either, but I should want the casting to look well, and, if it were a part of some machine, I should like it to compare in style and finish with the rest of the machine, and would be tempted to spend a little more time in shaping the pattern and then make it up in waxing and varnishing. Perhaps you wouldn't need to varnish at all, or at most one coat of varnish ought to do for a single casting, and then the new casting wouldn't look quite so much like a makeshift job. There are a great many repair jobs done "for ourselves, you know," which are prominent examples of one kind of economy; and, where the machine-work is done under the same system, the conomy of the job is apt to be lessened by the frequent tinkerings made necessary to keep the thing running.

Pride sometimes has a great deal to do with the cost of pattern work. Let a new man go into a shop where they think they do things a little bit nicer than any other shop, and he will think that unless he follows their style, or what he thinks is their style (he is just as likely as not to set his standard of excellency too high), they will think that he isn't much of a patternmaker. And so he will do just the nicest job that he can, and then he will perhaps be set down as a slow hand, or one that is too fussy about his work.

In many cases the foreman is to blame for this. It should be his business to so instruct a new man that he will understand just how good a pattern is wanted; but he doesn't always do this, although he generally does the best he can in his own way, and it is unfortunate for a new man that the way is not better. He is apt to put too much emphasis on the fact that we "allow $\frac{1}{8}''$ shrinkage, and want just $\frac{3}{32}''$ where the casting is to finish." Now, having impressed the man with the superior exactness of "our work," let him select the lumber for the man, condemning anything he may have already cut himself, and then watch him to see that he doesn't get a chance to use any of his own ideas, for, of course, the foreman's ideas are always the best, and in half a day the new man will be thinking what a fool he was to come to work in this shop, and, if he is at all nervous, he won't know whether he is afoot or horseback, and will consequently consume more time on the job than necessary. Then, toward the end, let the foreman tell him that he is anxious to get that cast to-day, and the new man will actually be ashamed of the pattern and of having been so long about it. If you wish to find out just what a man can do, give him a job with whatever instructions are necessary. Tell him that it is a job from which but one or two castings are to be made, then let him do the rest, and my word for it the job will give better satisfaction, both in time and finish.

I don't believe in making costly patterns for a job that will require only a few castings, and it is a mistake, many times, to make expensive patterns for what is called standard work, for this reason: Suppose you are manufacturing some special line of machinery, of course you will strive to keep your machine at the head, and to do this you must adopt all improvements, and by experiments try to better anything yet made. Thus, you see, your expensive patterns would soon be ruined by the alterations found necessary, when if you had made a cheap pattern to start with you could have remade it once or twice all through and still have kept the cost within reasonable limits. This constant alteration of patterns causes them to wear out much faster than the moulder would or should use them up.

By a cheap pattern I don't mean one that looks as if it had been hewed out with a broadaxe and then rubbed down by the moulder, but exercise a little common sense and make a pattern that can be moulded easily and nicely; don't leave so much for the moulder to do that the casting will become expensive by reason of the foundry work. A man who knows just what he wants to do and just how he is going to do it—two things, by the way, that are absolutely necessary to make a really cheap pattern—will cut his stuff just right the first time, and he would make every move count, provided he was allowed to carry out the original ideas. This, you see, would ensure a good, workmanlike job from the very start, and this would make a cheap pattern because there would be no time wasted.

In a great many cases patterns are good enough without fillets or without making-up nail-holes, and for a quick job it is usually best to do away with all cants and stave-work and put your pattern up solid. There are some few cases where cants or stave-work are necessary or where they will save time in the end.

When your pattern is all together, see if the moulder can work it without varnishing. In short, make every move count, and don't do anything that isn't absolutely necessary.

Even on regular work there is often a great deal of time wasted, although each one can best be his own judge in regard to this, for what one would consider essential another would condemn as foolish and unnecessary. It would, therefore, be impossible to say just how any one pattern should be made, and leave no room for improvement, so that it would be sure to please every man who had anything to do with it. Therefore it is likely that we shall just go on pleasing, or trying to please, the particular firm we may be working for, and when we go to another shop we can leave all of the foolish notions behind—and perhaps have to adopt some still more foolish.

CHAPTER II.

THE MARKING AND RECORD OF PATTERNS.

THERE are many good systems of marking patterns in operation, and it would be impracticable to devise any one system that would be best for all kinds of patterns. I will, therefore, confine myself to the description of a single system which has been found to work well for the class of goods for which it was inaugurated—goods for steam, water, and gas-fittings, with an occasional set of patterns for some special machine, to be used in the manufacture of the same.

This scheme was based on the vowel index, as commonly used, employing the five vowels, A, E, I, O, U. As soon as this point was reached, it was seen that the letters I and O would be confounded with figures one and nought, and as it was proposed to first fix the letter by scanning the name of the article to be named, using the first vowel *after* the first letter, and then to prefix a number for the kind or class of the article, it was decided to substitute K for I and T for O, thus making our five vowels A, E, K, T, U. And now for a practical example.

In practice, perhaps the first article made would be a 90° elbow. Here it will be seen that the first vowel *after* the first letter is O, but for O we have substituted T, thus the letter for 90° elbows is T, and as 90° elbows give us the first kind of patterns under the vowel O, we will prefix the figure 1, thus making the complete signature for this kind of pattern 1T. Then affix to this signature a serial number which shows at once how many patterns of this kind have been made, and gives to each pattern an arbitrary mark.

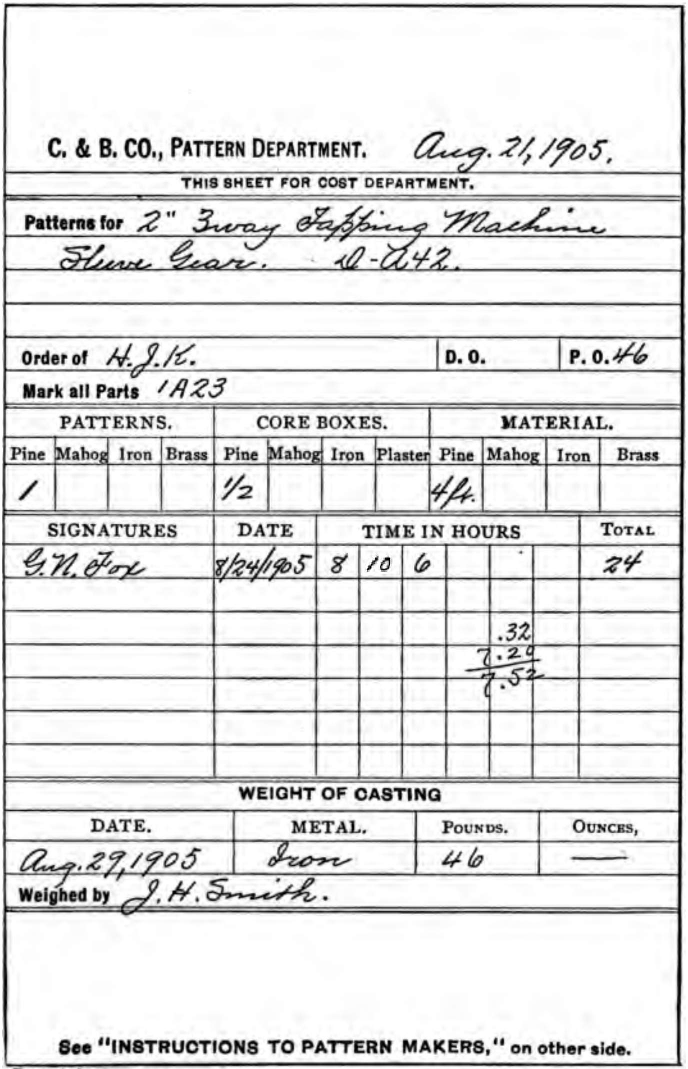
Very likely the next pattern required will be a 45° elbow. This would also come under T; and as this is the second kind of pattern coming under T, the signature will be 2T.

The third pattern to be made is perhaps a tee. This will come under E, and, being the first E, the signature will be 1E.

And now, having started to manufacture fittings, we find that a tapping-machine is necessary; and one having been designed, the patterns will require some mark. Following the rule of using the first vowel, A in this case, prefixed by 1, the signature is 1A; and the details, for which castings may be required, may be marked in rotation, according to their importance, 1A1, 1A2, 1A3, and so on through the complete list. If it was found necessary to make two sizes or kinds of tapping-machines, the second kind would be marked 2A1, 2A2, 2A3, and so on to the end of the chapter. If, in designing the second machine, it was found that some part of the first one could be used, enter on detail drawing the pattern mark, preceded by the word "Use," thus: Use 1A26; this would show the patternmaker at once that the pattern for this piece was already made.

And now having the drawings ready for the pattern shop, let us follow some one piece through the patternmaker's hands to its final resting-place in the safe.

The foreman of pattern shop will make out (through



C. & B. CO., PATTERN DEPARTMENT. Aug. 21, 1905.

THIS SHEET FOR COST DEPARTMENT.

Patterns for 2" 3way Tapping Machine
Sleeve Gear. D-A42.

Order of H.J.K. **D. O.** **P. O.** 46

Mark all Parts 1A23

PATTERNS.				CORE BOXES.				MATERIAL.			
Pine	Mahog	Iron	Brass	Pine	Mahog	Iron	Plaster	Pine	Mahog	Iron	Brass
1				1/2				4 ft.			

SIGNATURES	DATE	TIME IN HOURS						TOTAL
G. N. Fox	8/24/1905	8	10	6				24
						.32		
						7.20		
						7.52		

WEIGHT OF CASTING

DATE.	METAL.	POUNDS.	OUNCES,
Aug. 29, 1905	Iron	46	—

Weighed by J. H. Smith.

See "INSTRUCTIONS TO PATTERN MAKERS," on other side.

Form A front

INSTRUCTIONS TO PATTERNMAKERS.

Note carefully the material to be used in construction of patterns and core-boxes; and the number of pieces required.

Under heading, "Weight of Casting," note metal of which casting is to be made.

Wooden patterns and core-boxes for castings of brass should be finished with light-colored varnish, all other wooden patterns with black varnish, iron patterns to be finished with bayberry tallow, iron core-boxes with paraffine wax.

Wooden patterns should be finished all over with the same color unless otherwise ordered.

Tally each day's time separately. Date when finished and sign your name.

Charge amount of material in proper space under heading "Material."

This ticket should be promptly returned to foreman, that there may be no delay in making up costs.

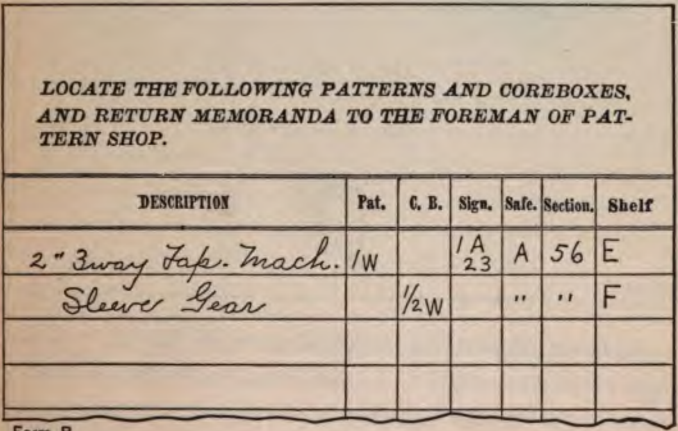
LUMBER TALLY

PINE																			
Length	2'		2'		1'														
Width	6"		6"		6"														
Thkns.	2"		1"		2"														
Feet	2		1		1														
MAHOGANY																			
Length																			
Width																			
Thkns.																			
Feet																			

Form A reverse

his clerk) a cost-sheet for each item or pattern, on form "A." This is turned over to the patternmaker, with the drawing, and shows him *what* is to be made, *how many* patterns and core-boxes are required, and the *material* of which they are to be made. There is room for one or more men to tally each day's time and lumber, and also a place to sign his or their name or names and enter date of completion, before turning in his sheet. The instructions on back of Form "A" reverse, will show him how to finish his job and how to charge the material.

The pattern, having been made, is then sent to the safe, the cost-sheet to the man who will weigh the casting and enter the weight on the cost-sheet, returning same to the pattern shop foreman, who usually has charge of the pattern storage; the drawing is returned to the drawing-room to be traced and printed, the Bp being sent to the machine-shop, the foreman of which will order the neces-



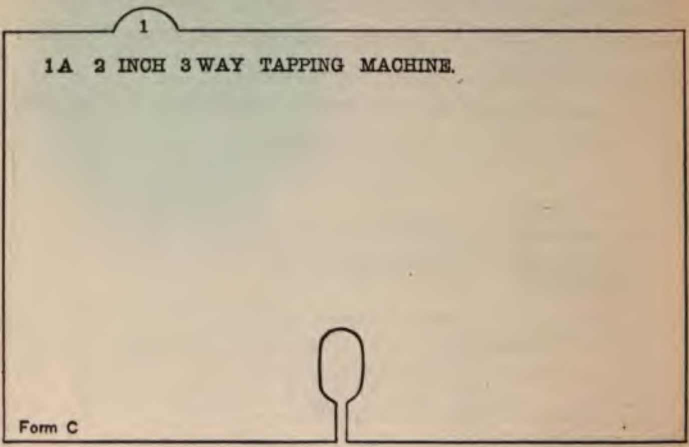
LOCATE THE FOLLOWING PATTERNS AND COREBOXES, AND RETURN MEMORANDA TO THE FOREMAN OF PATTERN SHOP.

DESCRIPTION	Pat.	C. B.	Sign.	Safe.	Section.	Shelf
2" 3way Tap. Mach.	1W		1A 23	A	56	E
Sleeve Gear		½W		"	"	F

Form B

sary castings. With the pattern is sent a location card, Form "B," which is filled out by the safe-keeper to show the location of patterns.

And now for the record, which was typewritten on cards and contained, in addition to the record proper, an index which recorded the signatures and tallied the serial number affixed to the signature.



1

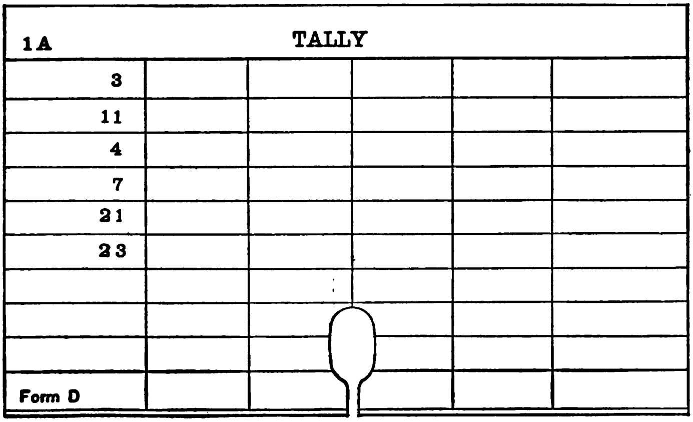
1A 2 INCH 3 WAY TAPPING MACHINE.

Form C

Referring first to this index, drawer, or file "A," tabbed and numbered card, "1" (see Form "C"), one of which is made out for each signature, and which are cut "twelfths" in the card-maker's language, the ten tabs from the right-hand side only are used, thus leaving a space at the left, which was originally intended to be occupied by a blue guide card (cut sixths), bearing the vowel.

The third tab from left hand, which is the first one used, was marked 1, 11, 21, and so on; the other nine tabs, counting toward the right, being marked according to their position, 2, 3, 4, and up to 0. The cards were filed in rotation, as used. This tab number shows the figure prefixed to the vowel in the signature, and as they are not filed until used, a glance at any file shows at once what the prefix should be for next kind of pattern coming under that vowel.

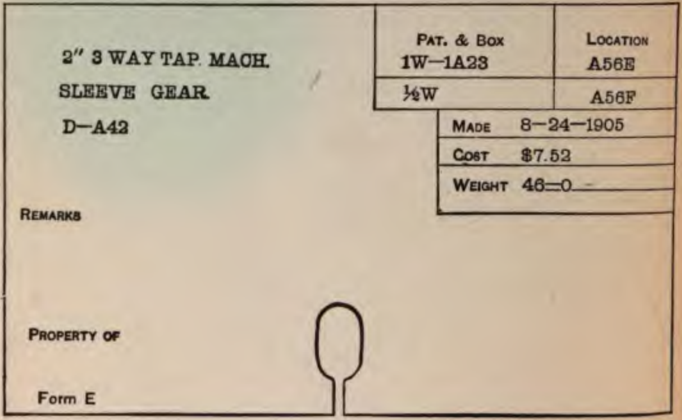
These tabbed cards were typewritten with the name or class of patterns, bearing the signature indicated by the file vowel and the tab number, and immediately behind the tabbed card was filed a tally card, Form "D," bearing the signature as per tabbed card C, and on which was recorded, or "tallied," the serial affix to signature as fast as used, thus showing at once the affix required for next pattern.



1A	TALLY				
3					
11					
4					
7					
21					
23					
Form D					

The record cards, printed as per Form "E," were made in three colors: salmon for gray iron castings, gray for malleable-iron, and white for brass or bronze, thus making it unnecessary to print this information on each card, and also enabling the user to pick out by the colors all patterns for any given material.

The record card shows, first, the name of the piece and number of drawing, then, under heading "Pat and Box," the number of patterns and the material of which they are made, "1W" signifying one pattern made of wood. Then the signature and affixed serial number, "1A23." This mark will always identify this individual pattern and its core-box, no other pattern having the same affix after the same signature. Thus, in speaking of pattern "1A23," you refer to this particular pattern and no other.



2″ 3 WAY TAP. MACH.
SLEEVE GEAR
D—A42

PAT. & BOX	LOCATION
1W—1A23	A56E
½W	A56F

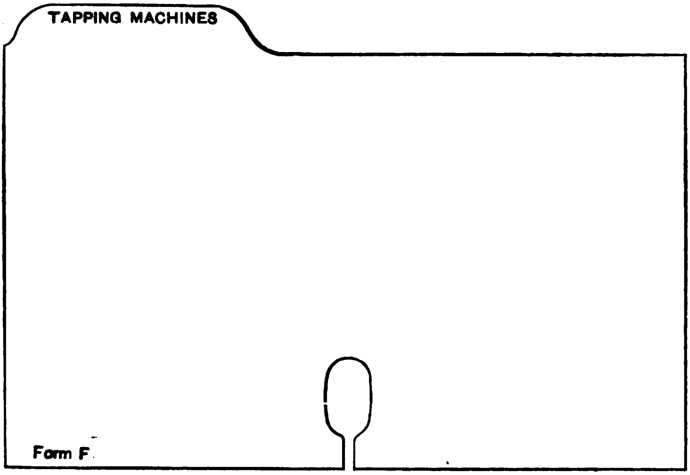
MADE 8—24—1905
COST $7.52
WEIGHT 46=0

REMARKS

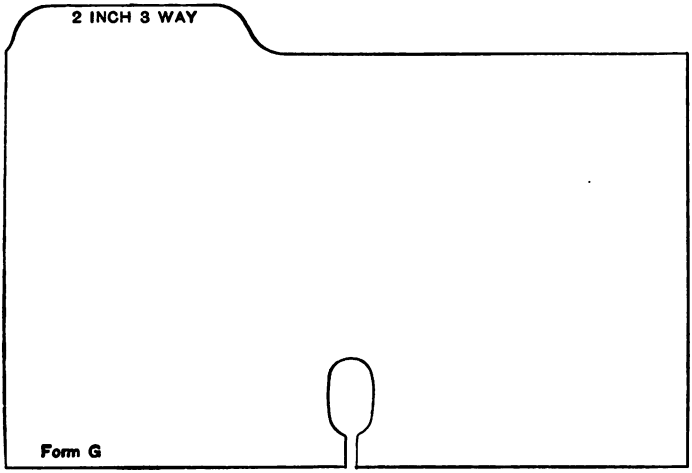
PROPERTY OF

Form E

In the space under "1W–1A23" is found a description of the core-box, "½W" meaning that there is only a half-box, which was all that it was thought necessary to furnish for this job, and that it was made of wood. To the right of description of pattern and core-box is written their location, "A56E," meaning that the pattern has been



Form F



Form G

placed or "located" in safe A, section 56, and on shelf E. The core-box is located, as shown, in the same safe and section, but on shelf F. This information was obtained from location card B.

The next line on record card E shows when the pattern was completed, and is simply a date. Then comes the cost, which is, in fact, only a portion of the entire cost, and includes only the labor and material shown on cost-sheet A, it being the practice of C. & B. Co. to obtain quotations from the pattern shop which included only the labor and materials, the cost department making all necessary additions for fixed expenses.

There is still another space for the weight of one or more castings from this pattern, the total weight being entered on upper line, and the number of pieces weighed on the lower line.

There are two other headings on record card, one for "Remarks," which requires no explanation, and the other "Property of," opposite which was entered the name of the firm which ordered and *paid* for the pattern.

In filing these record cards, several forms of guide cards, cut "thirds," were used. A blue, left-hand cut, Form "F," for the kind of goods, then a buff, left-hand cut, Form "G," for classes.

These were supplemented by "centre cut" buff cards for parts and "right-hand cut" buff cards for *kinds* of parts. In some cases these guide cards were still further subdivided by tabbed cards, having pipe sizes printed on the tab.

An almost infinite variety of guide cards can be had, so that any form of subdivision may be used.

CHAPTER III.

PATTERN ACCOUNTS.

I AM well aware that it is impossible to go into a complete detailed account of the proper method of placing the cost of patterns for all kinds of manufacturing in any single article or discussion. For this time I have in mind only that portion of the accounting which is supposed to show the firm the value of their patterns at the inventory taking.

This is still a very much complicated subject, as any one set of rules for depreciating their (the patterns') value cannot be made to apply to all kinds of patterns. Still a plan by which patterns may be accounted for from their actual cost, not by going to the expense of accounting each individual pattern separately—although this is done with machine-tools by many firms—but by grouping them in classes or kinds, or by time production, making a single item of all produced during one inventory period, or by a combination of the two, class and time, each item of the inventory might show the cost of one class of patterns produced between two inventories.

Thus we might go on dissecting our pattern record until it became so finely detailed as to show at any time the actual value of each and every pattern by depreciating its last inventory value by some prescribed or predetermined set of rules.

For the reason that all will not agree on the value of old patterns, and because the inventory must necessarily show the worth of *all* patterns, whether they are used in the actual production of the firm's output or are only necessary, and some of them seldom used accessories; for example, parts of fixtures and tools which are vitally necessary in the manufacture of the firm's product, and also such patterns as are made in repairing breakages, and in replacing worn parts of machinery; these must all have some value.

Whether it is considered best to put all of the patterns into one account, or, by keeping repairs and fixtures in a class by themselves, thus making two or more pattern-accounts, it will be necessary to fix upon some scheme for depreciation which shall free the account of patterns that have become useless or worn out.

First comes the question, "What adds to the total value of patterns?" New patterns will, of course; then the repairing of patterns, when done intelligently, certainly enhances their value, and in my opinion both of these items should be entered on the cost side of the account, especially when the cost is to be used as a basis for fixing inventory value, which is what I am proposing to do. We should now fix upon some period of time which shall represent the useful life of each pattern or class of patterns, or, what I should consider the more sensible and equally satisfactory way, upon a period which can be fairly considered as an average life for all patterns on hand.

This would greatly lessen the task of inventorying, and by readjusting the length of this period from time to time, as was found necessary, we could arrive at a much more satisfactory result, because we should always have a fixed value to start from, the length of the period constituting the useful life of the patterns having been fixed by some competent person.

I am aware that it is a very common practice to depreciate the entire account by a fixed percentage at each inventory, but this method often gives very unsatisfactory results. Let me illustrate. Patterns do not deteriorate as fast during the first part of their existence as later on, when they begin to need repairs, and toward the last of their usefulness they wear out pretty fast. For these reasons it does not seem right to depreciate the new patterns at the same rate as the old ones. Again, a flat reduction by a fixed percentage never entirely wipes out a pattern.

But as all of these points have been gone over many times, I am telling you nothing new, and will pass on to an explanation of the scheme which I consider an improvement, and I shall be pleased if it is of help to any one who has the patience to follow me through this somewhat uninteresting article.

The life of the pattern may be reckoned at any desired length of time, but, whatever period may be determined upon, the percentage of depreciation must be so arranged that at the end of its life you will have entirely wiped out its cost. A simple illustration will explain my proposition.

Suppose that a firm is producing $100 worth of patterns a year, and has been doing so for at least ten years in succession. Suppose, also, that ten years has been fixed upon as an average life of all patterns, the pattern inventory may now be taken from the account in the manner shown by Table III.

TABLE III.

INVENTORY SHEET BASED ON A TEN-YEAR LIFE.

Year Made.	Cost.	1st Year 10% Off.	2d Year 20% Off.	3d Year 30% Off.	4th Year 40% Off.	5th Year 50% Off.	6th Year 60% Off.	7th Year 70% Off.	8th Year 80% Off.	9th Year 90% Off.	10th Year 100% Off.	Value Dec. 31st.
1900	$100.00	......	......	......	......	......	......	......	......	.....	.....	$100.00
1901	"	$90.00	......	......	......	......	......	......	......	.....	.....	190.00
1902	"	"	$72.00	......	......	......	......	......	......	.....	.....	262.00
1903	"	"	"	$50.40	......	......	......	......	......	.....	.....	312.40
1904	"	"	"	"	$30.24	......	......	......	......	.....	.....	342.64
1905	"	"	"	"	"	$15.12	......	......	......	.....	.....	357.76
1906	"	"	"	"	"	"	$6.05	......	......	.....	.....	363.81
1907	"	"	"	"	"	"	"	$1.72	......	.....	.....	365.53
1908	"	"	"	"	"	"	"	"	$0.34	.....	.....	365.87
1909	"	"	"	"	"	"	"	"	"	$0.03	.....	365.90
1910	$100.00	$90.00	$72.00	$50.40	$30.24	$15.12	$6.05	$1.72	$0.34	$0.03	$0.00	365.90

Here is shown each year's production, which is used as a single item in making up the inventory, also the depreciation of each item by an increasing percentage, beginning with 10 per cent. and ending with 100 per cent., thus making no mention of a pattern which is ten or more years of age.

This table is only given as an illustration, and may, of course, have the actual production entered, and also have the depreciation rates varied to suit needs of users. The only fixed point being that each item, whether it represents a single pattern, a class of patterns, or the entire production, is accounted for by itself, and is entirely wiped out at the end of the predetermined period, the last depreciation being final, or 100 per cent.

The table as constructed shows only one complete inventory, that for the year 1910, but for the supposed conditions you will note that this inventory equals 265.9 per *cent.* of yearly production plus the last year's production, and as long as production remains the same, and other conditions are not changed, the inventory value will remain fixed, as it certainly should.

This same table will also serve to illustrate the case of a firm just beginning manufacturing. The supposition that they will spend exactly $100 each year for patterns is, of course, highly improbable, but it will serve just as well to illustrate my proposition; and if the annual expenditure continues to be the same after the ten years accounted for in the table, the inventory will also continue fixed, which seems to me to be an extremely rational and likely result.

Again, if this is acknowledged to be a probable result in the suppositious case just cited, would it not be equally correct in an actual case? The only practical difficulty is the fixing of the actual annual cost of patterns, for after the cost has once been fixed the taking of an accurate inventory is very simple. Any one who keeps a pattern account may inaugurate this system by going back in the account for ten years and substituting the actual cost for each year in place of the supposed annual cost of $100 in the table shown. Or if the life period of ten years is thought to be too short or too long, let him substitute any other period which may be deemed more in accord with prevailing conditions, and construct a table containing whatever number of years may be decided upon as the useful life of the patterns to be accounted for. There must necessarily be *some* limit to this period, as all will agree that a pattern which has ceased to be useful has also ceased to be of any value as a pattern, and can only be reckoned as so much waste material.

TABLE IV.

INVENTORY FOR FIFTEEN-YEAR LIFE.

Cost		$100.00
1st yr.	6% off	94.00
2d "	7% "	87.42
3d "	9% "	78.55
4th "	12% "	69.12
5th "	16% "	58.06
6th "	21% "	47.87
7th "	26% "	34.04
8th "	32% "	23.15
9th "	40% "	13.89
10th "	50% "	6.95
11th "	60% "	2.78
12th "	70% "	.83
13th "	80% "	.17
14th "	90% "	.02
15th "	100% "	.00
Inventory value		$616.85

TABLE V.

INVENTORY FOR TWENTY-YEAR LIFE.

Cost		$100.00
1st yr.	5% off	95.00
2d "	5% "	90.25
3d "	10% "	81.22
4th "	10% "	73.10
5th "	15% "	62.15
6th "	15% "	52.81
7th "	20% "	42.25
8th "	20% "	33.80
9th "	25% "	25.35
10th "	30% "	17.44
11th "	35% "	11.63
12th "	40% "	6.98
13th "	45% "	3.84
14th "	50% "	1.92
15th "	55% "	.86
16th "	60% "	.34
17th "	70% "	.10
18th "	80% "	.02
19th "	90% "	.002
20th "	100% "	.000
Inventory value		$699.34

For the sake of comparison I give two examples in Tables IV. and V., one illustrating the proposition on a basis of fifteen years, and the other based on a twenty-year life. Personally I am of the opinion that a ten-year life is rather too long, but as it offers a simple and easily reckoned account, I have used it as an example.

The yearly depreciation may be at any rate which is thought to best fit the conditions, but the final year's rate must be 100 per cent. It will also be seen that the longer the life, the larger the inventory becomes; for ten years the value (at the rates given) is 365.9 per cent., in the fifteen-year example it is 616.85 per cent., and for the twenty-year life it amounts to 699.34 per cent.

The fifteen-year case brings the inventory, much nearer to the twenty-year than to the ten-year. This apparent irregularity is caused by the varying rates of depreciation, the ten-year table giving a regularly increasing rate through the whole life of the pattern, while the twenty-year depreciation is much slower, only reaching, at the end of the seventh year, the rate used for the second year of the ten-year case, but reducing the last half of the pattern value at the same rate as the ten-year.

Still another rate of depreciation is shown in the fifteen-year example. While these illustrations serve to show the elasticity of the method, they all arrive at the same desirable end—the pattern disappears when it is worn out.

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